Eng. Div. Files

BRISTOL HARBOR
RHODE ISLAND

SURVEY
(REVIEW OF REPORTS)

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

DEC 1966

SYLLABUS

The Division Engineer finds that Bristol Harbor is exposed to storm waves from the south to southwest direction that hamper the use of existing vessels and inhibit the growth of the fishing and recreational fleets. He finds that benefits to vessels to be obtained by protecting the harbor by means of a breakwater oriented normal to the southwest direction are sufficient to warrant Federal participation. He therefore recommends a project to provide for a breakwater 1600 feet long, with a top elevation of 10 feet above mean low water beginning at a point about 400 feet west of the Coast Guard pier and extending generally in a northwesterly direction. The estimated cost of the structure is $1,364,000 (1966), and $24,000 for aids to navigation.

The project is recommended subject to the requirement that local interests contribute 36 percent of the construction cost, said contribution presently estimated at $491,000. The net cost to the United States is $873,000 for construction, and $24,000 for aids to navigation. The benefit-cost ratio is 1.5.

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U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASS. 02154

ADDRESS REPLY TO:
DIVISION ENGINEER

REFER TO FILE NO. NEDED-R

7 December 1966

SUBJECT: Survey (Review of Reports) Bristol Harbor, Rhode Island

TO: Chief of Engineers
ATTN: ENGCW-P

AUTHORITY

1. This report is submitted in compliance with the following resolution adopted 29 July 1955 by the Committee on Public Works of the House of Representatives:

> "RESOLVED BY THE COMMITTEE ON PUBLIC WORKS OF THE HOUSE OF REPRESENTATIVES, UNITED STATES, That the Board of Engineers for Rivers and Harbors be, and is hereby, requested to review the reports on Bristol Harbor, Rhode Island, heretofore submitted to the Congress, with a view to determining what improvements for navigation are advisable at this time in Bristol Harbor, Rhode Island."

2. A preliminary examination was completed in August 1958. The preliminary results indicated that a survey study was warranted and was authorized.

PURPOSE AND EXTENT OF STUDY

3. The present study is made to determine the economic justification of improving Bristol Harbor for navigation in accordance with the desires of local interests. In preparation of this report a detailed hydrographic survey was made in 1961 to obtain soundings and probings in the area desired for improvement. A public hearing

was held at Memorial Hall, Colt High School, Bristol, Rhode Island on 11 December 1957. The Bristol Harbor Development Commission provided a great deal of useful information. Local interests and other agencies were consulted to obtain their comments on the result of the study. Information furnished at the hearing was confirmed and updated through meetings and correspondence with local interests during the course of this study.

DESCRIPTION

4. Bristol Harbor is located on the east side of Narragansett Bay about 13 miles southeast of the city of Providence. The harbor is a cove, approximately 2 miles long in a north-south direction with a width of 1.3 miles at its mouth and 0.4 mile wide at its head. It is separated from Mount Hope Bay by Bristol Neck on the east and from Narragansett Bay by Popasquash Neck on the west. Depths vary from 12 to 27 feet in the harbor. Hog Island separates the entrance into 2 channels. The business section of the town and the wharves including a United States Coast Guard Depot are located on the eastern side of the harbor. Depths at piers and wharves range from 9 to 13 feet. A yacht club, boat yard and small boat piers exist along the west shore generally at the north end of the harbor. The harbor is sheltered from the north, east, and west by the mainland and it is partially sheltered by Hog Island to the south. The longest effective fetch is 14 miles in a south-southwest direction. The mean range of tide is 4.1 feet and the spring range is 5.1 feet. The maximum tidal height of record was 16.0 feet above mean low water during the hurricane of September 1938. The locality is shown on Coast and Geodetic Survey Charts Nos. 278, 353 and 1210, on the U. S. Army Map Service Topographic quadrangle of Bristol and on the maps accompanying this report.

TRIBUTARY AREA

5. The immediate tributary area is the Town of Bristol with a population of 15,716 in 1965. The town has a number of diversified industries, including manufacture of wire and cable, rubber shoes, and thread, the fishing industry and the manufacture of plastic textile machine parts, plastic boats and other plastic products. The

commercial wholesale shellfish business located in Bristol Harbor is the biggest concentration in the state and accounts for approximately one-sixth of the Rhode Island catch. Shellfish is shipped from Bristol to other states as far south as Virginia. Bristol is accessible over state highways connecting with United States highways from Providence and Fall River. It is served by a freight line of the New York, New Haven and Hartford Railroad from Providence. A ferry line operating out of Bristol Harbor provides the only public transportation to Prudence and Hog Islands in Narragansett Bay.

BRIDGES

6. There are no bridges crossing any portion of the waterway under consideration in the report.

PRIOR REPORTS

7. Bristol Harbor has been the subject of two prior unpublished navigation reports of preliminary examination scope. Both reports were unfavorable to navigation improvement. The first report dated 1 December 1925 considered deepening the harbor to 30 feet. It was found that the existing harbor depths were adequate for present and reasonably anticipated future navigation developments. The second report, dated 23 December 1927, considered removal of the remains of a rock-filled turning pier, deemed a navigation hazard, situated opposite Steamboat Wharf. It was found that navigation would be protected by marking the obstruction and that its removal was not warranted.

EXISTING CORPS OF ENGINEERS PROJECT

8. There is no existing Federal navigation project for Bristol Harbor and therefore no local cooperation has been required.

OTHER IMPROVEMENTS

9. Except for navigation aids maintained by the United States Coast Guard, there has been no Federal or local improvement for navigation of the waterway.

TERMINAL AND TRANSFER FACILITIES

10. The developed waterfront of Bristol Harbor is concentrated along approximately a half-mile stretch of the east shore of the harbor. In this section of the harbor there are six privately owned landings, two owned by the Town, one by the State and one by the Federal Government. All private landings are of granite construction and some have pile fenders, all have truck access, two have railroad access, two have gasoline and one has diesel oil service. These docks are used primarily for landing shellfish. Other commercial uses include dock building facilities and a ferry terminal. There is a town pier at Rockwell Park which accommodates approximately 50 small boats and a town wharf at State Street used for larger transient craft. The State landing at Church Street includes finger piers for use by larger craft. All three above described piers (two Town and one State) are open to the public. There is also a State constructed launching ramp at State Street for public use.

IMPROVEMENT DESIRED

11. To determine the nature and extent of improvement desired by local interests, a public hearing was held at Colt High School, Bristol, Rhode Island on December 11, 1957. The hearing was well attended by State and Town officials, members of the Bristol Harbor Development Commission, representatives of yachting interests, local business interests, boat owners, and other interested individuals.

12. The Bristol Harbor Development Commission submitted a report at the hearing which states that the most needed navigation improvement in Bristol Harbor is a breakwater which would be located south of the commercial and industrial section on the east side of Bristol Harbor. The proposed breakwater, 1000 to 1600 feet long, would extend across the lower end of the harbor offshore of the vicinity of Union Street, and would be of a type to afford reasonable protection for the area immediately north of the structure. The suggested breakwater was strongly supported by most of those that spoke as their concern was principally the protection of the developed waterfront and also to obtain a protected anchorage area. Two other breakwater locations were suggested, one further south below the Herreshoff Yacht Yard, to protect the entire developed waterfront of

the east side of the harbor, the other farther north to protect a shorter extent of the shore front north of the United States Coast Guard wharf.

13. It was stressed that storms originating from the southeast to southwest quadrant resulted in rough seas within the harbor, creating conditions unfavorable to boat anchorage. It was stated that winds as low as 25 miles per hour created these conditions and that protection could be provided by the construction of a breakwater. The possibility of harbor improvement by dredging shallow areas in the lee of the most southerly proposed breakwater and also the dredging of a channel at the head of the harbor into Mill Pond was pointed out by one individual. There was no other support by the local interest for the proposed dredging.

14. Subsequent to the hearing, in August 1958, representatives of the Harbor Development Commission stated a preference for a breakwater to extend from the vicinity of the State pier westward for a distance of about 1000 feet. Consideration was desired of incorporating sheet piling with stone riprap for a distance of 200 to 350 feet from which finger piers could be constructed. It was further stated that a breakwater which included the Coast Guard pier would probably be too costly for the Town to participate in its construction. In 1962, local interests reaffirmed their preference for an offshore breakwater, abreast of the U. S. Coast Guard pier.

EXISTING AND PROSPECTIVE COMMERCE

15. The United States Waterborne Commerce Statistics for the period 1955 through 1964 indicate that the average annual commerce consists of about 1040 tons of commodities (excluding non-typical year 1962), and passenger traffic of about 36, 870 people. During 1964, the latest year for which statistics are available, the commerce in Bristol Harbor amounted to 1236 tons, with passenger traffic amounting to 43, 283 people. This commerce consists principally of supplies shipped by ferry to Prudence Island, and is exclusive of fish landings at Bristol Harbor.

Year	Tonnage[3]	Passengers	Vessel Trips	Year	Tonnage[3]	Passengers	Vessel Trips
1955	1019	-[1]	1852	1960	1013	35,642	1740
1956	848	-[1]	1850	1961	929	29,916	2182
1957	837	-[1]	1844	1962	2977[2]	35,466	1777
1958	747	-[1]	1760	1963	1128[3]	41,058	1874
1959	808	35,372	1718	1964	1236	43,283	1866

(1) Not known
(2) Reason for variation not known
(3) All tonnages are n. e. c. (not elsewhere classified) except 1963 tonnage includes 5 tons shellfish

16. Landings of shellfish are made in the harbor. The United States Fish and Wildlife Service reports that about 2-3/4 million pounds of shellfish are landed in Bristol Harbor and handled by the following fish dealers: Moran's Shellfish Company, Bristol County Shellfish Company, and Sousa Dock. The proposed improvement is desired for the protection of the small fishing boats and fishing gear. The U. S. Fish and Wildlife Service states that a breakwater would reduce storm damages to fishing boats and increase available anchorage area. However, it does not evaluate the benefits that would accrue due to protection of the harbor. There is listed below the fish landings (all shellfish) for the most recent 10 years.

Year	Shell Weight (in pounds)	Value	Year	Shell Weight (in pounds)	Value
1956	7,557,000	$414,527	1961	2,797,000	$157,379
1957	6,064,000	408,920	1962	2,215,000	146,483
1958	4,204,000	307,721	1963	2,482,000	222,500
1959	3,361,000	258,392	1964	2,646,000	235,490
1960	4,003,000	274,220	1965	2,732,000	201,860

Discussion with the Bureau of Commercial Fisheries of the very large decline in shellfish landings from 1956 through 1962 and then the steady growth from 1962 through 1965 leads to the conclusion that the decline was principally due to damage to the shellfish beds in the 1954 and 1955 hurricanes, and to the increasing limitations imposed because of pollution. The conclusion was also reached that there is no reason why the present annual rate of recovery or growth of shellfish catch (averaging 7. 5 percent per year) will not continue.

This conclusion includes assessment of increasing activity in pollution control, and increasing demand due to population increase.

VESSEL TRAFFIC

17. The total number of vessel trips reported in the Waterborne Statistics for 1964 is 1, 866. These are trips made by the Prudence Island Navigation Company. Based on past information, it is estimated that the Coast Guard makes about 500 trips annually.

In addition, there is substantial traffic created by the locally based commercial boats and recreational craft. The existing commercial fleet consists of 21 fishing boats ranging in length from 28 to 83 feet, drawing 3 to 4-1/2 feet, and valued at $104, 000; about 50 hand rakers, 14 feet in length, valued at $50, 000, and four charter ferry boats valued at $155, 000. Total commercial fleet amounts to 75 craft. The recreational fleet amounts to a total of 261 vessels composed of the following classes:

Type of Craft	Length	No. of Craft	Value
Outboards	10-20	65	$ 39, 000
Inboards	10-20	44	52, 800
Cruisers	15-30	26	104, 000
	31-50	12	120, 000
Aux. Sails	15-30	25	117, 500
	31-40	2	20, 000
	41-60	8	128, 000
Sailboats	10-20	70	56, 000
	21-30	9	16, 200
	Total	261	$653, 500

DIFFICULTIES ATTENDING NAVIGATION

18. The harbor has sufficient area and depth but is exposed to waves from southerly directions. Present use of the waterfront is hampered whenever winds of 25 miles per hour or over occur from southerly directions, due to waves generated by the winds.

WATERPOWER AND OTHER SPECIAL SUBJECTS

19. The waterway under consideration is tidal. There are no problems involved in this investigation pertaining to waterpower or pollution. The improvement under consideration would have no significant effect on tidal flooding during high level storms or hurricanes.

PROJECT FORMULATION

20. Bristol Harbor is a natural cove situated on the east side of Narragansett Bay, a popular water area used extensively by recreational craft. The Bay area also supports a substantial fishing and shell fishing industry. The natural depths in Bristol Harbor are adequate for the type and size of craft presently using or anticipated to use the harbor. The primary need for improvement is the protection of vessels from waves originating from the southwest quadrant. Seven alternative plans of breakwater protection were studied based on these premises. These seven alternative plans are described as follows:

a. Offshore breakwater across harbor mouth, south of Coast Guard Pier area rather than opposite or north of Coast Guard Pier. This plan would require a longer breakwater, in deeper water, to protect a similar area of the harbor. The additional outer harbor area protected would be farther removed from shore and of doubtful use. Consequently, it is concluded that the additional benefits, if any, would not be commensurate with the added cost.

b. A shore based breakwater, bent to lie off the outer ends of the wharves in the vicinity of the Coast Guard Pier. This plan would offer the most complete protection of that immediate area, but the protected area would be too small for the present and prospective fleets.

c. System of three breakwaters (a detached, central breakwater across the middle of the harbor mouth, and two overlapping shore-based breakwaters located several hundred feet from the central

breakwater, one to the north and one to the south). This system would provide more complete protection to the inner harbor, particularly along the shore. However, the additional benefit beyond that afforded by a single central breakwater is not sufficient to warrant the added cost.

d. As a result of the above analysis, alternative plans were then considered consisting of variations of length and height of a breakwater across the central portion of the harbor. These variations are called Plans 1, 2, 3, and 4. Plans 1, 2, and 3 are for breakwaters with a top elevation of 10 feet above mean low water (5.9 feet above mean high water), and would be 1000, 1300, or 1600 feet long, respectively. Plan 4 is for a breakwater with a top elevation of 22 feet above mean low water, and is 1600 feet long. The comparisons of Plans 1, 2, and 3 are based on the relative costs, and relative benefits each would provide. The benefits are directly proportional to the area of shelter provided by each plan, which, in turn, determines the size of the navigation fleet benefited. Plans 1 and 2 would not afford sufficient shelter to protect the entire existing fleet and a reasonable expansion of the fleet anticipated during project life. A breakwater of greater length than 1600 feet would cost more, and based on the estimates of fleet size and protected area needed, would not add any benefits. Plan 3 therefore provides for the maximization of benefits to be derived by protecting navigation from the usual range of storms. Plan 4 would be for a higher breakwater to provide protection during hurricanes. Plan 4 would cost $1,174,000 more than Plan 3, and the added annual benefits would exceed the added annual costs by $9,300, thus providing a maximum of benefits to costs of all plans considered.

21. One of the primary reasons for the request by local interests for breakwater protection at Bristol Harbor was to protect the boats and shore facilities from damage by waves generated by high level storms and hurricanes. The design height of a breakwater that would protect the harbor for navigation from the usual high level storms would not effectively protect it from hurricanes. Such protection would necessitate a substantially higher breakwater (Plan 4). This structure would not significantly reduce tidal flooding damage, a major portion of hurricane damage in the town. The additional benefits from a higher structure over those attainable under the proposed plan (Plan 3) would be those attributable to reduced wave damage during the relatively infrequent storms of hurricane intensity. Since the widespread damage

due to tidal flooding would not be mitigated by a larger structure, local interests demonstrated very little interest in participating in the higher cost of such a structure, even though the additional benefits slightly exceeded the additional cost. The recommended breakwater (Plan 3) could be enlarged to provide a top elevation of +22 feet mean low water, as in Plan 4, and thus maximize the net benefits in the event it becomes necessary and desirable to do so in the future.

22. The area being studied is entirely within the range of tides; consequently, there are no considerations of water quality, pollution or recreational facilities other than those associated with navigation.

PLAN OF IMPROVEMENT

23. Bristol Harbor has depths that are adequate for the types and size of commercial and recreational craft that use or are anticipated to use the harbor. The harbor is sheltered from all quadrants except from the south. The location of Bristol Harbor is such that the fetch for winds emanating from the south to southwest is sufficient to generate waves of damaging heights. Local interests desire breakwater protection against waves generated by southerly storms, including hurricanes.

24. Wind and wave studies to evaluate probable wave heights and studies of the reductions of wave heights by wave diffraction showed that a breakwater 1,600 feet in length, starting approximately 400 feet from the U. S. Coast Guard pier, would be effective in protecting the east side of the inner harbor from waves originating from the southwest quadrant. (See Appendix E, Breakwater Design). This location was selected as the most feasible location to construct a breakwater, economically, without interfering with operations of the Coast Guard depot. A decrease in breakwater length results in a difference in the amount of protected anchorage area. A 1600-foot breakwater was found to be necessary to provide sufficient area, adequately protected for the existing fleet and for the reasonable expansion of the fleet during the life of the project. The structure would provide protection from all waves

originating between the south and the southwest directions. The wharves on the east side of the harbor would not be completely protected from waves originating in the southeast quadrant. However, waves from that quadrant would be smaller in height and would not require the measures that are needed to protect the area against waves from the southwest.

25. Consideration of wind speeds and fetch results in selection of a design wave of 7 feet. For that wave, the breakwater should have a top elevation of 10 feet above mean low water (about 6 feet above mean high water), side slopes of 1 vertical to 1-1/2 horizontal and a top width of 10 feet.

26. Four plans of improvement were considered in detail during the study for comparative purposes and to provide a basis for evaluating and selecting the most economical and feasible plan. Plans were considered for a breakwater, 1000, 1300 and 1600 feet in length, respectively, at elevation +10 above mean low water; top width of 10 feet and side slopes of 1 on 1.5, and a fourth plan consisting of a 1600-foot breakwater with top elevation 20 feet above mean low water.

27. The most feasible plan that would meet the needs of navigation is found to be a breakwater 1600 feet long, with a top elevation of 10 feet above mean low water and a top width of 10 feet. (See Pars. 20d. and 21 concerning maximization of benefits that would be provided by a higher breakwater affording more protection from hurricanes, but the inability of local interests to assume the higher costs entailed.)

SHORELINE CHANGES

28. The shoreline of the harbor is generally rocky, consisting of large areas of ledge outcrop. Because there is no movement of littoral materials, it is considered that the construction of a breakwater would have no effect on the configuration of the adjacent shoreline.

REQUIRED AIDS TO NAVIGATION

29. The United States Coast Guard has been consulted with respect to the need for additional aids to navigation for a breakwater in Bristol Harbor. They advised that aids to navigation necessitated by such an improvement would have an initial cost of $24,000 with an annual maintenance cost of $600. The U. S. Coast Guard report is included in Appendix C.

ESTIMATES OF FIRST COST

30. Estimates of first costs have been made for breakwaters of various lengths and heights. These estimates are included in Appendix A. The breakwaters considered would be rubble mound structures of local stone with construction accomplished from floating plant. The estimated first cost of the breakwater selected for construction based on prices prevailing in June 1966 is as follows:

Feature	Cost
Stone Breakwater, 1600 ft. long; top width of 10 feet, at elev. +10 above MLW	$1,063,000
Contingencies	160,000
Construction Cost	$1,223,000
Engineering and Design	40,000
Supervision and Administration	101,000
Total Construction Cost	$1,364,000*
Aids to Navigation	24,000
Total Project Cost	$1,388,000

*Exclusive of $7500 for preauthorization studies.

ESTIMATE OF ANNUAL CHARGES

31. The estimated annual carrying charges for the improvements considered in the report have been computed for a life of 50 years at an interest rate of 3-1/8%. The annual charges are computed on the total investment, Federal and non-Federal, to achieve the improvement. Non-Federal investment will consist of a cash contribution based on the proportion of local benefits to the total benefits. Adequate public landings are presently available to navigation in the harbor.

32. The estimate of annual breakwater maintenance is based on repairs similar to those required on like structures in New England. The average annual maintenance cost is estimated at $6,000.

33. The average annual charges for the selected plan, including Federal and non-Federal charges, are as follows:

Total Investment (including Aids to Navigation)	$1,388,000
Interest & Amortization 50 yrs @ 3-1/8% (.03979)	55,230
Annual Maintenance	
Breakwater	6,000
Aids to Navigation	600
TOTAL ANNUAL CHARGES (Federal and Non-Federal)	$ 61,830

ESTIMATES OF BENEFITS

34. Protection of Bristol Harbor from storm and wave action originating from the south to southwest directions would result in benefits to the existing and prospective fleets of commercial and recreational craft as well as to waterfront structures. Tangible benefits from such improvements would accrue through increased use of the existing fleet based in the harbor, the addition of new boats to the local fleet, and reduction of damage to vessels and shore facilities.

35. Recreational benefits for improvement of Bristol Harbor have been estimated for the existing fleet of 261 locally based craft ranging from outboards to cruisers and auxiliary sailboats. The composition of the existing fleet is given in paragraph 17 and in Table I. A protected harbor will result in expansion of the existing fleets. An immediate increase of 40 boats is estimated to occur with an additional gradual growth over the 50-year life of the project. The protected harbor areas were divided into three categories: areas subjected to waves of one foot or less; one foot to 1.5 feet; and 1.5 feet to 2.0 feet under storm conditions. It was considered that 10 boats an acre could moor safely when subjected to waves up to 1 foot in height, that 8 boats an acre could moor safely when subjected to waves between 1 foot and 1.5 feet, that 5 boats an acre

could moor safely when subjected to waves between 1.5 feet and 2.0 feet. This estimate of intensity of anchorage use is based on free-swinging mooring, with the mooring radius of adjacent boats overlapping so that each boat has a clear half-circle of mooring area. Other factors affecting the estimate of mooring density include boat length, and depth of water which affects the anchor chain scope. The density of mooring thus obtained was scaled down, as a matter of judgment, to allow more space where the degree of exposure toward the edges of the sheltered area, and wave height, increased. It is considered undesirable to use an area as a mooring area when waves are greater than 2.0 feet in height.

36. The extent of protection afforded by breakwaters of various lengths has been determined and is tabulated below:

Breakwater Length (feet)	Area with less than 1 foot wave	Area with wave of 1-1.5 feet	Area with wave of 1.5-2 feet	Total Area
1,600	40 acres	17 acres	18 acres	75 acres
1,300	24 acres	13 acres	12 acres	49 acres
1,000	11 acres	9 acres	6 acres	26 acres

Using the above criteria, the maximum number of boats that could safely use Bristol Harbor with breakwaters of 1600 feet, 1300 feet and 1000 feet are 626, 404, and 212 respectively. A 1000-foot breakwater is found to provide insufficient protection for the existing fleet and therefore is given no further consideration. A breakwater 1300 feet long is found to provide for limited expansion of the existing fleet and the total benefits anticipated to accrue from the improvement would provide only marginal justification for a Federal project. In view of the continual upsurge in recreational boating in the Narragansett Bay area, a structure of 1300-foot breakwater would rapidly become inadequate. Therefore, the benefit evaluation for a breakwater 1600 feet long is given in this report. Comparative benefits with the other breakwater lengths are shown in Appendix A.

37. Benefits for the recreational fleet have been evaluated as the gain in annual return which the owner of the craft would enjoy if improvements were made. The annual net return to the owners of recreational boats has been taken as the net amount the owners would receive if they chartered their boats to others. The value of this gain is expressed as a percentage of the current market value of the fleet. The gain represents the difference between present use of the harbor and the increased use that will be made possible as a result of improvement.

Ideal return varies according to the size and type of boat. For this report, the ideal return would range from 13 percent for outboards to 8 percent for the larger boats.

38. Increased use of the harbor would be a primary benefit accruing from the breakwater protection. The boating season in this area extends from 1 May through 30 September or 150 days. Wind records of speed, direction and duration show that during the above boating season the winds are predominantly from the southerly quadrant. It is estimated that winds of all speeds from the south are generated about 50% of the time and that winds in excess of 8 miles per hour occur 40% of the time, in excess of 12 miles per hour 25% of the time, and winds in excess of 16 miles per hour occur 10% of the time.

39. The exposure of Bristol Harbor to the south reduces the use of the recreational fleet in the harbor. The difficulties and unpleasant conditions experienced by recreational craft in the harbor under present degrees of exposure discourage full potential use of the present fleet, partly because of difficulty in mooring and unmooring during periods of moderate to somewhat stronger winds, or in going to and from shore in small craft from the anchored boats. The accumulated effect of these various detractions from use of the fleet is estimated to result in the present value of the use of Bristol Harbor by the existing fleet ranging from 75% of the ideal benefit for the smaller craft to 90% of ideal for the larger boats. The composition of the existing recreational fleet and estimated annual benefits to the existing fleet from a protected harbor are shown in Table L. The net benefit is computed to be $10,600.

40. The central location of the harbor in Narragansett Bay makes it attractive for recreational boating. The Bristol Yacht Club regatta consistently leads the other bay regattas in attendance. Local interests state that over 700 transient vessels visit the harbor during the year at an average stay of about 4 days each. It is estimated that for a 150-day boating season, the transient vessels are equivalent to 20 permanently based boats. The transient fleet would receive benefits comparable to the existing fleet. The

composition and benefit evaluation to the transient fleet are shown in Table II. The net benefit to the present transient fleet is computed to amount to $1, 250. The average benefit per boat is about $60. With provision of breakwater protection, it is reasonable to consider that the number of transients will increase. It is estimated that a 20% increase in transient traffic would occur immediately resulting in an additional 4 equivalent permanent boats for a benefit of $250.

41. The shoreline of the Narragansett Bay area has been extensively developed for recreational purposes, particularly in the form of yacht clubs, private marinas, and public-owned shore facilities. With improvement of Bristol Harbor, to the extent of protecting its exposure to the south, this natural harbor with adequate depths for recreational and commercial craft would have increased attractiveness to small craft. Local interests claim that with a protected harbor the existing fleet will expand at least 50%. It is considered that within a relatively short period of time after construction of the breakwater that a 15% increase in the permanent fleet, or about 40 boats, will occur. Table III evaluates the benefit to the increased fleet of 40 boats under this benefit.

42. It is further considered that over the project life the remaining capacity of the protected harbor will be utilized through expansion of the permanent fleet. This expansion would be assured due to the great interest in recreational boating as evidenced by the rapidly increasing numbers of recreational boats in recent years and the projected increase in population, leisure time and income. Table IV evaluates the benefit to the remaining capacity of the harbor that will be used over the life of the project. These plans will provide 75 acres of protected area estimated to have a capacity of 626 boats. The remaining capacity of the harbor after provision for existing craft is 320 boats. Allowing for the immediate growth, the residual capacity due to the plan is 276 boats. This represents about a 100% growth in 50 years over that expected immediately after improvement or about 2% per year. A recent "Projective Economic Studies of New England" prepared by Arthur D. Little, Inc. for the Corps of Engineers forecasts that the population of Rhode Island will more than double by year 2020.

TABLE I
BENEFITS TO RECREATIONAL BOATING
EXISTING FLEET

HARBOR: Bristol Harbor, R. I.

TYPE OF CRAFT	LENGTH (feet)	No. of Boats	DEPRECIATED VALUE AVERAGE $	DEPRECIATED VALUE TOTAL $	PERCENT RETURN IDEAL	% OF IDEAL Pres.	% OF IDEAL Future	GAIN	VALUE $	ON CRUISE AVG. DAYS	ON CRUISE % of SEASON	VALUE $
RECREATIONAL FLEET												
Outboards	10-20	65	600	39,000	13	75	100	3.25	1,267			
Inboards	10-20	44	1,200	52,800	11	75	100	2.75	1,452			
Cruisers	15-30	26	4,000	104,000	9	80	100	1.80	1,872	8	5	93
	31-50	12	10,000	120,000	8	90	100	0.80	960	15	10	96
	51-60											
Aux. Sail	15-30	25	4,700	117,500	9	80	100	1.80	2,115	8	5	105
	31-40	2	10,000	20,000	8	90	100	0.80	160	15	10	16
	41-60	8	16,000	128,000	8	90	100	0.80	1,024	15	10	102
Sailboats	10-20	70	800	56,000	12	75	100	3.00	1,680			
	21-30	9	1,800	16,200	11	75	100	2.75	445			
	31-40											
	41-60											
CHARTER BOATS												
Cruisers	21-35											
	36-50											
	51-100											
TOTALS		261		$653,500					$10,975			$412

Net Benefit = $10,975 - $412 = $10,563 Say $10,600

TABLE II

BENEFITS TO RECREATIONAL BOATING

HARBOR: Bristol Harbor, R. I. TRANSIENT FLEET

TYPE OF CRAFT	LENGTH (feet)	No. of Boats	DEPRECIATED VALUE AVERAGE $	DEPRECIATED VALUE TOTAL $	PERCENT RETURN IDEAL	% OF IDEAL Pres.	% OF IDEAL Future	GAIN	VALUE $	ON CRUISE AVG. DAYS	ON CRUISE % OF SEASON	ON CRUISE VALUE $
RECREATIONAL FLEET												
Outboards	10-20											
Inboards	10-20											
Cruisers	15-30	4	4,000	16,000	9	80	100	1.80	288			
	31-50	1	10,000	10,000	8	90	100	0.80	80			
	51-60											
Aux. Sail	15-30	5	4,700	23,500	9	80	100	1.80	423			
	31-40	2	10,000	20,000	8	90	100	0.80	160			
	41-60											
Sailboats	10-20	5	800	4,000	12	75	100	3.00	120			
	21-30	2	1,800	3,600	11	75	100	2.75	99			
	31-40	1	8,000	8,000	10	90	100	1.00	80			
	41-60											
CHARTER BOATS												
Cruisers	21-35											
	36-50											
	51-100											
TOTALS		20		$85,100					$1,250			

TABLE III

BENEFITS TO RECREATIONAL BOATING

HARBOR: Bristol Harbor, R. I.

NEW BOATS (immediate)

TYPE OF CRAFT	LENGTH (feet)	No. of Boats	DEPRECIATED VALUE AVERAGE $	DEPRECIATED VALUE TOTAL $	PERCENT RETURN IDEAL	% OF IDEAL Pres.	% OF IDEAL Future	GAIN	VALUE $	ON CRUISE AVG. DAYS	ON CRUISE % of SEASON	ON CRUISE VALUE $
RECREATIONAL FLEET												
Outboards	10-20	10	600	6,000	13	0	100	13	780			
Inboards	10-20	7	1,200	8,400	11	0	100	11	924			
Cruisers	15-30	4	4,000	16,000	9	0	100	9	1,440	8	5	72
	31-50	2	10,000	20,000	8	0	100	8	1,600	15	10	160
	51-60											
Aux. Sail	15-30	4	4,700	18,800	9	0	100	9	1,692	8	5	85
	31-40	1	10,000	10,000	8	0	100	8	800	15	10	80
	41-60	2	16,000	32,000	8	0	100	8	2,560	15	10	256
Sailboats	10-20	9	800	7,200	12	0	100	12	864			
	21-30	1	1,800	1,800	11	0	100	11	198			
	31-40											
	41-60											
CHARTER BOATS												
Cruisers	21-35											
	36-50											
	51-100											
TOTALS		40		$120,200					$10,858			$653

Net Benefit = $10,858 - $653 = $10,205, Say $10,200

TABLE IV

BENEFITS TO RECREATIONAL BOATING

HARBOR Bristol Harbor, R. I. NEW BOATS (future)

TYPE OF CRAFT	LENGTH (feet)	No. of Boats	DEPRECIATED VALUE AVERAGE $	DEPRECIATED VALUE TOTAL $	PERCENT RETURN IDEAL	% OF IDEAL Pres.	% OF IDEAL Future	GAIN	VALUE $	ON CRUISE AVG. DAYS	ON CRUISE % of SEASON	ON CRUISE VALUE $
RECREATIONAL FLEET												
Outboards	10-20	69	600	41,400	13	0	100	13	5,382			
Inboards	10-20	47	1,200	56,400	11	0	100	11	6,204			
Cruisers	15-30	27	4,000	108,000	9	0	100	9	9,720	8	5	486
	31-50	16	10,000	160,000	8	0	100	8	12,800	15	10	1,280
	51-60											
Aux. Sail	15-30	26	4,700	122,200	9	0	100	9	10,998	8	5	550
	31-40	3	10,000	30,000	8	0	100	8	2,400	15	10	240
	41-60	9	16,000	144,000	8	0	100	8	11,520	15	10	1,152
Sailboats	10-20	75	800	60,000	12	0	100	12	7,200			
	21-30	8	1,800	14,400	11	0	100	11	1,584			
	31-40											
	41-60											
TOTALS		280		$736,400					67,808			$3,708

Net Benefit = 67,808 - 3,708 = 64,100

Av. Annual Equivalent over life of project 64,100 x 0.03866 = 24,781, Say 24,800

43. Local interests furnished data on experienced damages to the commercial and recreational craft from storms, other than hurricanes, from the southerly direction. From an evaluation of the damages claimed by individual boat owners and the boat repair yards, it is estimated that average annual damages from storm action are incurred at the following rates:

(a) $530 a year for large commercial boats, (b) $100 a year for small commercial boats, (c) $70 a year for recreational boats. Benefits accruing to the commercial fleet are considered general in nature, while benefits to recreational craft are considered 50 percent general and 50 percent local. The benefits to the existing commercial and recreational fleet due to reduced damages are computed as follows:

a. Existing commercial fleet (25 vessels; including ferries)

25 vessels @ $530	=	$13,250

b. Existing commercial fleet (small vessels)

50 vessels x $100	=	5,000

c. Existing recreational fleet

261 vessels x $70	=	18,300

44. Under storm conditions, waves generated from the south cause damages to shore structures, which would be prevented or reduced by the breakwater. Although some of these damages result from storm waves impinging directly on the structure, damage to the structures is caused by vessels moored to them. This is especially true in the case of the marina facilities at the State pier and at the private small boat piers. There are about 15 piers on the east side of the harbor which would be protected by the proposed breakwater. Local interests did not furnish specific data as to the extent of the damage. From the general information furnished it is conservatively estimated that each of the 15 piers sustains damage in the amount of $100 annually for a total damage of $1500. Elimination of this damage is considered to be a benefit incidental to the harbor improvement project and general in nature.

45. The U. S. Fish and Wildlife Service did not evaluate benefits which would result due to improved harbor conditions. However, local interests furnished information on the effect of the harbor exposure to fishing vessels. A shellfish company reports that during periods of bad weather, boats land their catch at Tiverton or Newport at an added cost to the fishermen. This added cost is claimed to be a landing charge of about 15 cents per bushel for shellfish as well as transportation cost for delivery to Bristol. Another company claimed that for 30 to 40 days a year shellfish are landed at nearby harbors and then trucked to Bristol, involving costs of $700 to $800. Based on wind duration and frequency from the south and the intensity of waves that would preclude landings at Bristol, it is estimated that the conditions that would prevent landings would occur about 1/6 of the time, and therefore about 1/6 of the catch would be landed elsewhere. The added cost for landing and transporting this catch to Bristol is conservatively taken at 50 cents per bushel, or at a weight of 85 pounds per bushel, the cost is $0.00588 per pound. Projecting the rate of growth experienced since 1962 over the estimated project life from 1970 to 2020, it is estimated the annual shellfish landings at Bristol Harbor will pass the 1956 volume of 7,557,000 pounds at about the mid-point of the project life, and will reach a total of 11,850,000 pounds, or 57 percent in excess of the 1956 landings by the end of the 50 year project life. The benefit due to elimination of this cost of partial landings at other ports is estimated as follows:

Volume fish landings 1962	2,215,000 lbs.
Increase in fish landings 1962 - 1970	
2,215,000 x 0.075 x 8	1,329,000 lbs.
Volume in 1970	3,544,000 lbs.
Increase in volume 1970 - 2020	
2,215,000 x 0.075 x 50	8,306,000 lbs.
Volume in 2020	11,850,000 lbs.
Benefit due to cost savings on fish landings	
3,544,000 x 1/6 x $0.00588	$3,475
+ 8,306,000 x 1/6 x 0.00588 x 0.3866	3,150
	$6,625
Say	$6,500

46. The benefits anticipated to accrue as a result of providing breakwater protection for Bristol Harbor are summarized as follows:

Type of Benefit	Benefit Value
Recreational Craft:	
Increased use existing fleet	$10,600
Increased use existing transient fleet	1,250
New transients (immediate)	250
New Local Boats (immediate)	10,200
New Boats (future)	24,800
Reduced damage	18,300
	$65,400
Fishing Fleet and Ferry Boats:	
Reduction of damage	18,250
Saving in cost of fish landing	6,500
	$24,750
Shore Facilities:	
Reduced pier damage	1,500
Total	$91,650

47. The foregoing benefits from the proposed breakwater plan are further summarized according to type and apportioned as general or local benefits, as follows:

Benefits to	Total	General	Local
Recreational craft	65,400	32,700	32,700
Fishing craft	24,750	24,750	0
Shore facilities	1,500	1,500	0
Total	91,650	58,950	32,700
% of Total	100	64	36

COMPARISON OF BENEFITS TO COST

48. Comparison of the estimated annual benefits from the proposed plan and the annual charges for the plan result in the following benefit to cost ratio:

Estimated Annual Benefits	$91,650
Estimated Annual Charges	61,830
Benefit Cost Ratio	1.5

PROPOSED LOCAL COOPERATION

49. The benefits to be derived from improvement of Bristol Harbor are partly local and partly general in nature. In the case of the proposed breakwater, the most feasible and economical plan, the

local benefits are estimated as 36 percent of the total benefits. Since local interests should share in the project costs commensurate with the local benefits to be derived, it is determined the local interests should make a cash contribution of 36 percent of the construction cost of the breakwater, exclusive of aids to navigation. The local cash contribution is estimated at $491,000 (1966). Local interests have been consulted and have provided reasonable assurance that the above described requirements of local cooperation would be met.

50. For projects of this type, it is usual to require that a public landing open to all on equal terms be provided. In the harbor there are three public landings available. In addition, there are other recreational landings that are open to business. However, local interests should provide assurances that the existing public landings or their equivalent will be adequately maintained during the life of the project and will be open to all on equal terms.

51. Local interests should provide, without cost to the United States, all lands, easements, and rights-of-way necessary for construction and maintenance of the project when and as required. Rights-of-way should include access to a contractor with his equipment. Local interests should also hold and save the United States free from damages that may result from either the construction works or maintenance.

APPORTIONMENT OF COSTS AMONG INTERESTS

52. Costs for the improvement under consideration have been apportioned between the United States and local interests so that the Federal and non-Federal share of the first cost of construction are in the same ratio as the evaluated general and local benefits. Therefore 36 percent of the construction cost has been apportioned to local interests as a cash contribution. Other Federal costs include the costs of additional navigation aids. The construction cost for the breakwater is presently estimated at $1,364,000, exclusive of $24,000 for aids to navigation. The Federal and non-Federal investment resulting from this apportionment are as follows:

Federal Investment	
Corps of Engineers	
Project Construction (0.64) ($1,364,000)	$873,000
Coast Guard	
Navigation Aids	24,000
TOTAL FEDERAL INVESTMENT	$897,000

Non-Federal Investment

Cash Contribution (0.36) (1,364,000)	$ 491,000
TOTAL NON-FEDERAL INVESTMENT	$ 491,000
TOTAL INVESTMENT	$1,388,000

COORDINATION WITH OTHER AGENCIES

53. All Federal, State and local interests having an interest in the improvement of Bristol Harbor were notified of the public hearing held 11 December 1957. Officials of the State of Rhode Island, the town of Bristol and pleasure boat and fishing interests were consulted during the study concerning the improvement being considered. The tentative findings of the study were discussed at a meeting with local interests and they were given an opportunity to comment on the results and to indicate their willingness to participate in a project. By letter dated 1 March 1966, the Division of Harbors and Rivers of the Rhode Island Department of Natural Resources commented that the proposed project appeared to be satisfactory and should afford the needed protection. The Department made no commitment concerning the requirements of local cooperation but indicated past financial participation by the State of Rhode Island in projects of this kind. By letter dated 18 May 1966, the Town Council of Bristol concurred in the plan of improvement and stated that the improvement is necessary for the continued development of the waterfront and was of the opinion that the Town would be willing and able to meet the requirements of local cooperation at the appropriate time. The above letters from the State and Town are included in Appendix D of this report. These letters reflect an earlier apportionment of 37 percent of project costs to local interests, later superseded by the present apportionment of 36 percent of project costs to local interests.

54. The United States Coast Guard was advised of the improvements under consideration and was requested to comment on aspects pertaining to their interests. By letter of 21 May 1965, the Commander of the First Coast Guard District replied that a breakwater will require a fixed structure at each end with a daymark and a light. Comment was made relative to the location of the structure with respect to the Coast Guard Pier. Recommendation was made to move the breakwater north of the depot or shortened so that a safe approach by the tender

is assured. By letter of 14 February 1966, the Coast Guard concurred in a modified plan having a 300-foot minimum approach channel to the depot. Concern was expressed with respect to shoaling due to the structure and the need for dredging. It is not anticipated that shoaling will occur.

The U. S. Coast Guard letter is attached as Appendix C of this report.

55. The Regional Office of the United States Fish and Wildlife Service was also requested to comment on the plan of improvement. Their report (see Appendix B) indicated that the improvement would benefit the local fishing fleet through reduced storm damages and improved anchorage conditions. The report indicated that the proposed breakwater would have no significant adverse effect on fish and wildlife.

DISCUSSION

56. The Narragansett Bay area is presently extensively developed and with normal growth over the next 50 years most of the land will be completely utilized for residential, commercial, and industrial purposes. The Bay area has been and is becoming increasingly the most popular area for recreational boating. It is one of the more prolific shellfish producing areas and supports a fishing fleet of substantial size. The popularity of the area is attested by fact that of the more than 20, 000 recreational craft registered in Rhode Island in 1964 all but 5% are located in Narragansett Bay. The growth of recreational boating in the area in the past decade has been of such magnitude that availability of adequate mooring and berthing space has not kept pace with this growth.

57. Bristol Harbor within the complex of Narragansett Bay is a natural harbor with depths well in excess of those required for the recreational and fishing craft that use Narragansett Bay. It is approximately in the geographic center of the bay and the natural protection afforded by the harbor makes it attractive to small craft. Its primary disadvantage, which local interests desire to mitigate, is its exposure to wind and wave action from the southerly quadrants.

During the summer months, when the area is extensively used by recreational craft, the predominant winds are from the south to southwest. Waves generated from that direction roll into the harbor and affect the fleet based there from moderate discomfort to substantial damage to craft and to shore facilities.

58. A review of present use by fishing and recreational craft, the activity of marine related industries such as boat building activity, commercial and public marina installations, and transportation by ferries indicates the advisability of providing protective measures. It has been determined that presently there is a substantial use of the harbor by recreational and fishing craft and that existing traffic is hampered by wave action. It is considered that with protection of the harbor from the south, and because of its location within an area with continually expanding water use, that use of Bristol Harbor will expand.

59. Local interests requested consideration of a breakwater ranging from 1000 to 1600 feet in length to protect the harbor at one of several locations. Studies made to determine the location showed the most suitable location to be about abreast of the Coast Guard Depot. Plans of improvement considered included breakwater lengths of 1000, 1300, and 1600 feet at a height adequate to protect against southerly storms and oriented normal to the southwest direction. It was found that a breakwater 1000 feet long would not protect sufficient area to accommodate the existing fleet. Breakwaters 1300 and 1600 feet long were found to be justified but that maximum benefits would be obtained from a breakwater 1600 feet long. The 1300 foot breakwater would permit only limited expansion of the existing fleet, and would not adequately provide for the future growth of the fleet.

60. The benefits to be derived from the improvement are general in nature for the reductions in costs to fishing boat owners for landing their fish catch and reduction in damages to fishing craft, and equally general and local in nature as to benefits from recreational boating, such as a result of increased use by the pleasure craft, additions to the fleet, and reduction in storm damage. A general benefit is realized due to reduction of damages to piers. In addition,

there would be substantial benefits to the local economy which are considered to be secondary and are not evaluated in this report. The total benefits to accrue from the improvement (1600-foot breakwater) would be $91,650 of which 64 percent are general and 36 percent local.

61. An improvement that would adequately provide for present and prospective use would cost $1,364,000 for construction which would be shared 64 percent and 36 percent, Federal and non-Federal, respectively. In addition, there would be other Federal costs of $7,500 for preauthorization studies and $24,000 for additional navigation aids. The total Federal and non-Federal cost for a 1600-foot breakwater project is estimated as (July 1966) $1,388,000, exclusive of preauthorization studies.

62. The evaluated annual benefits of $91,650 when compared to the computed annual charges of $61,830 indicate a benefit-cost ratio of 1.5 for the 1600-foot breakwater.

63. The 1600-foot breakwater plan considered to be the most economically feasible improvement for the harbor was described to local interests and the relative merits of structures of varying heights and length were discussed in detail. Local interests concurred with the selected plan and indicated an interest and willingness to meet the requirements of local cooperation. Coordination with the U. S. Coast Guard revealed an approval of the plan in general but with a reservation as to possible shoaling in the approach channel to the Coast Guard Depot. It is not believed such shoaling would in fact occur. The U. S. Fish and Wildlife Service finds that a breakwater plan would have no adverse effect on fish and wildlife resources and that such a plan would benefit the industry through reduction of vessel damage.

CONCLUSIONS

64. It is concluded that existing conditions of Bristol Harbor are such that protection of the harbor from storms originating in the southerly quadrants is needed and justified.

The desires of local interests and the present and prospective needs of navigation at Bristol Harbor would be met by a Federal navigation project to provide a breakwater 1600 feet in length to protect the inner harbor area from waves originating from the south to southwest direction.

RECOMMENDATIONS

65. In view of the foregoing, the Division Engineer recommends that a project be adopted for Bristol Harbor, Rhode Island to provide for a breakwater 1600 feet long, with a top width of 10 feet at elevation 10 feet above mean low water, as shown on the map attached to this report.

66. The total estimated construction cost of the recommended breakwater is presently estimated at $1,364,000 (1966). The average annual maintenance cost is estimated at $6,000.

67. The project is recommended subject to the condition that local interests agree to:

a. Make a cash contribution of 36% of the first cost of construction of the breakwater, said contribution currently estimated at $491,000 (1966) to be paid in a lump sum prior to initiation of construction, and subject to final adjustment after actual costs have been determined.

b. Provide, without cost to the United States, all lands, easements, and rights-of-way necessary for construction and maintenance of the project when and as required. Rights-of-way should include access to a contractor with his equipment to construct the breakwater from land.

c. Hold and save the United States free from damages that may result from construction and subsequent maintenance of the project.

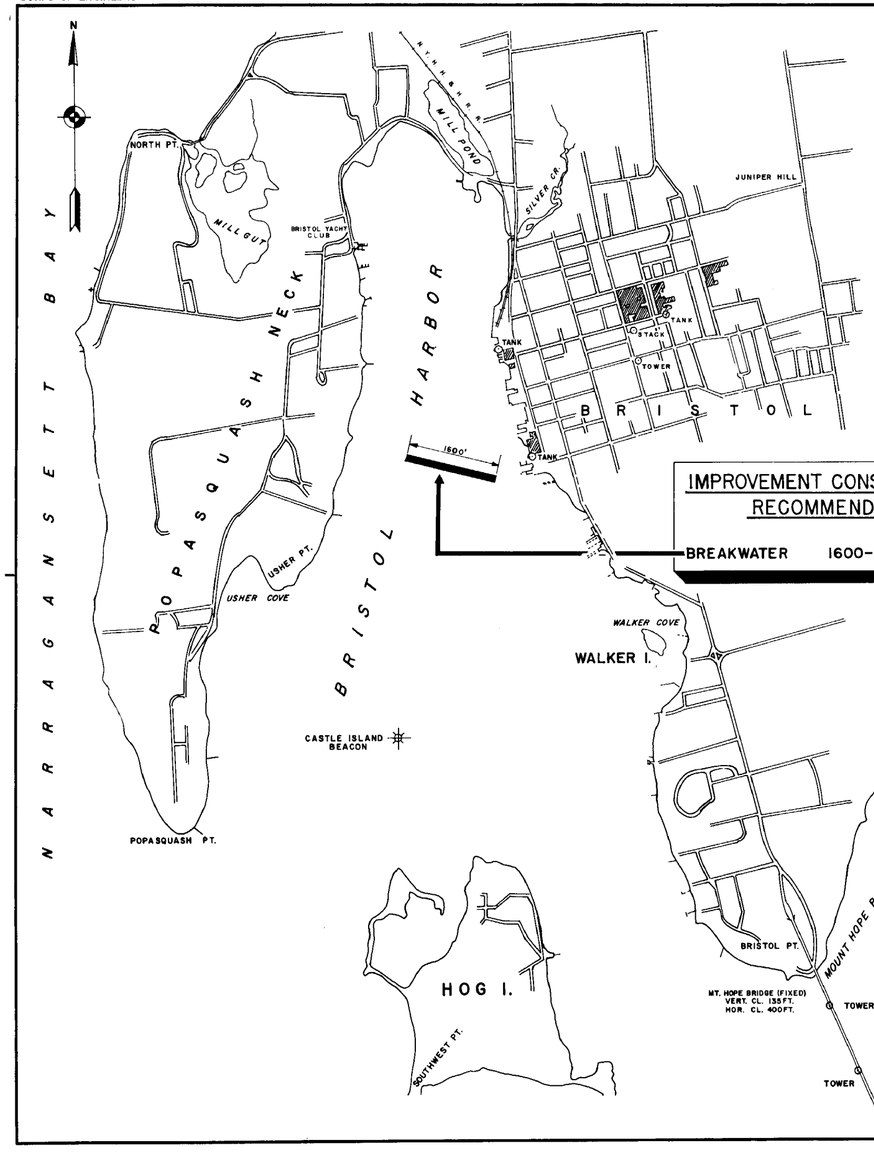
d. Provide assurances that the existing public landings or their equivalent will be adequately maintained during the life of the project and will be open to all on equal terms.

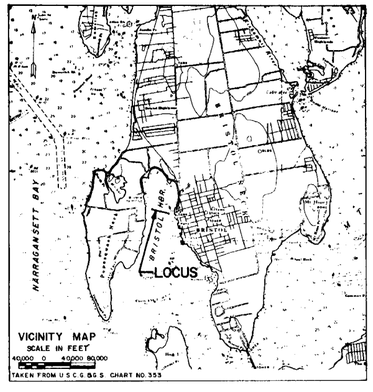
e. Establish regulations prohibiting discharge of untreated sewage, garbage and other pollutants in the waters of the harbor by users thereof, which regulations shall be in accordance with applicable laws or regulations of Federal, State and local authorities responsible for pollution prevention and control.

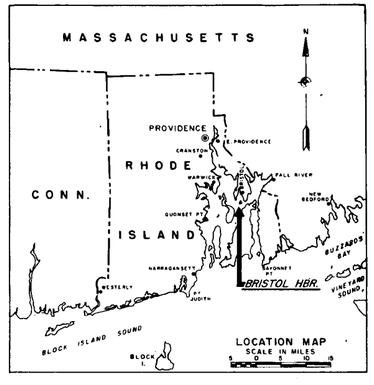
REMI O. RENIER
Colonel, Corps of Engineers
Acting Division Engineer

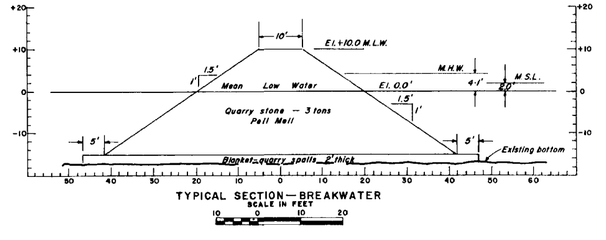
CORPS OF ENGINEERS

U. S. ARMY









REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

CH. BY	TR. BY	CK. BY
S.J.S.	S.J.S.	C.E.G.

PROJECT ENGINEER

SUBMITTED:
CHIEF, COASTAL DESIGN BR.

APPROVED:
CHIEF, PLANNING DIVISION

APPROVED:
CHIEF, ENGINEERING DIVISION

DATE: DEC 1966

BRISTOL HARBOR, BRISTOL, RHODE ISLAND

SCALE IN FEET
1000 0 1000 2000

TO ACCOMPANY REPORT
DATED: 7 DECEMBER 1966

SCALE AS SHOWN

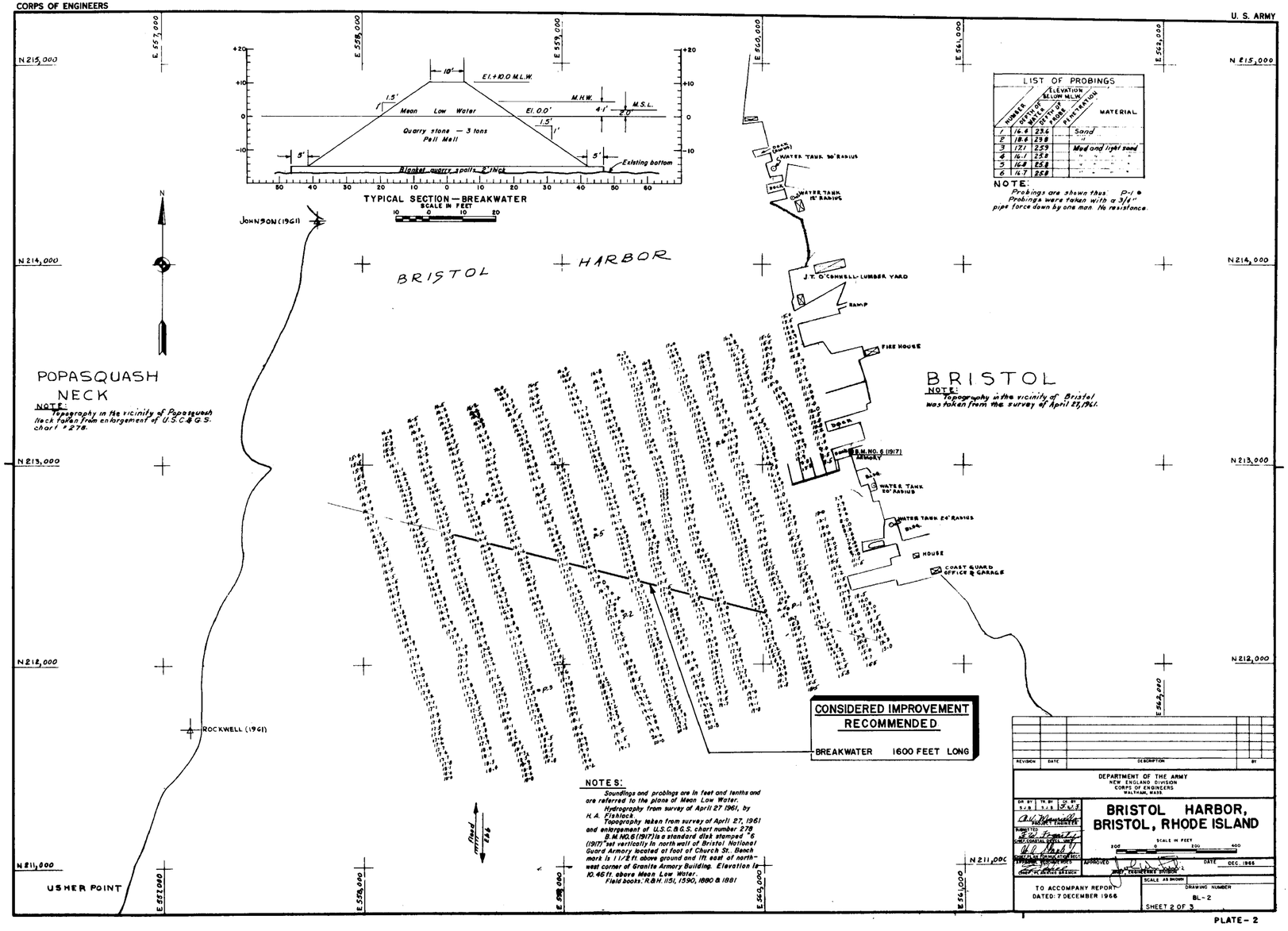
DRAWING NUMBER
BL-2

SHEET 1 OF 3

PLATE - 1

CORPS OF ENGINEERS

U. S. ARMY



LIST OF PROBINGS

NUMBER	DEPTH OF WATER	ELEVATION BELOW M.L.W. OF BOTTOM	DEPTH OF PENETRATION	MATERIAL
1	16.6	23.6		Sand
2	18.6	29.8		"
3	17.1	23.9		Mud and light sand
4	16.1	25.8		"
5	16.8	25.8		"
6	14.7	25.8		"

NOTE:
Probings are shown thus. P-1 ●
Probings were taken with a 3/4" pipe force down by one man. No resistance.

NOTE:
Topography in the vicinity of Popasquash Neck taken from enlargement of U.S.C.&G.S. chart # 278.

NOTE:
Topography in the vicinity of Bristol was taken from the survey of April 27, 1961.

NOTES:
Soundings and probings are in feet and tenths and are referred to the plane of Mean Low Water.
Hydrography from survey of April 27 1961, by H.A. Fishlock
Topography taken from survey of April 27, 1961 and enlargement of U.S.C.&G.S. chart number 278
B.M. NO. 6 (1917) is a standard disk stamped "6 (1917)" set vertically in north wall of Bristol National Guard Armory located at foot of Church St. Bench mark is 1 1/2 ft. above ground and 1ft east of northwest corner of Granite Armory Building. Elevation is 10.46 ft. above Mean Low Water.
Field books: R.B.H. 1151, 1590, 1890 & 1881

REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DR BY	TR BY	CH BY
S.B.	T.J.S.	J.C.J.

CHIEF, ENGINEERING DIVISION

BRISTOL HARBOR, BRISTOL, RHODE ISLAND

SCALE IN FEET
200 0 200 400

APPROVED
CHIEF, ENGINEERING DIVISION
DATE DEC. 1966

TO ACCOMPANY REPORT DATED: 7 DECEMBER 1966

SCALE AS SHOWN

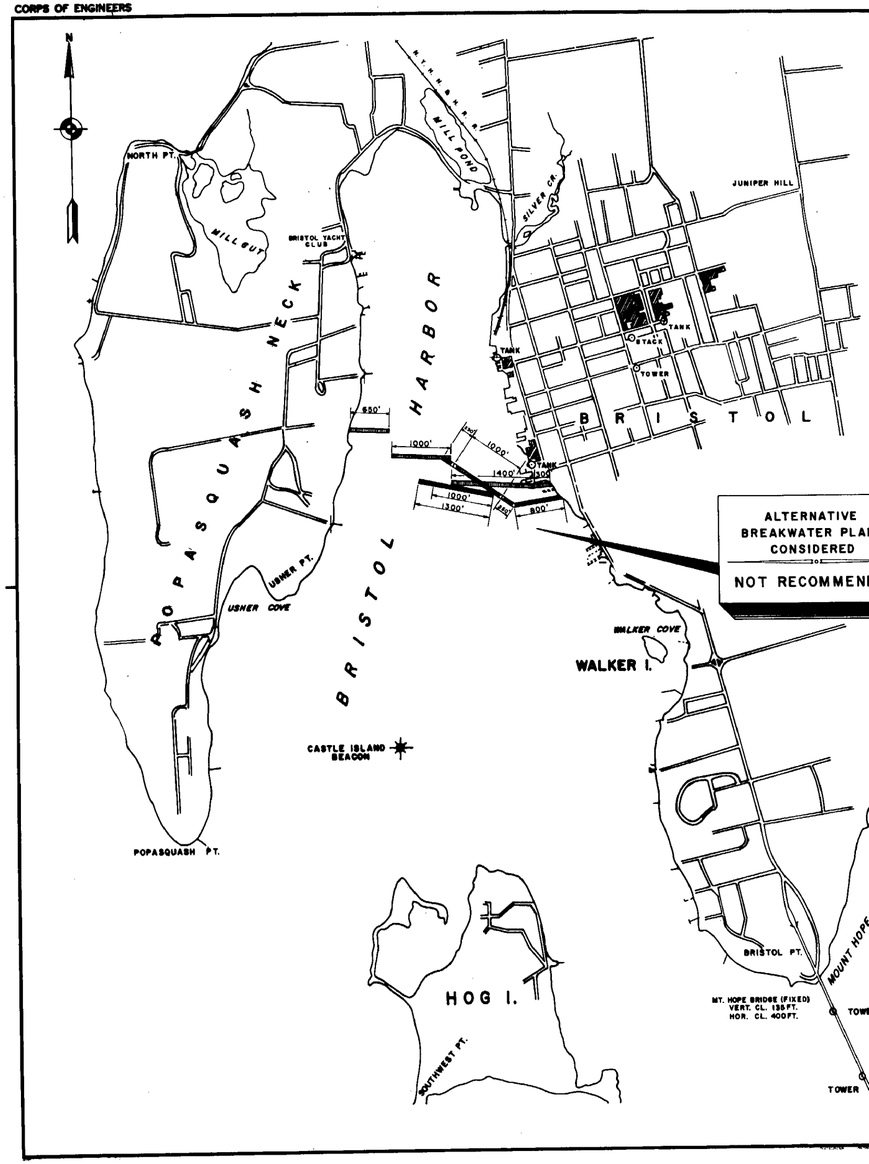
DRAWING NUMBER
BL-2

SHEET 2 OF 3

PLATE - 2

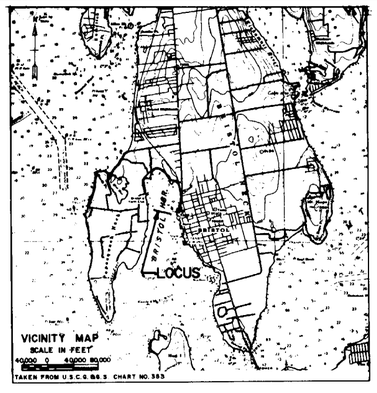
CORPS OF ENGINEERS

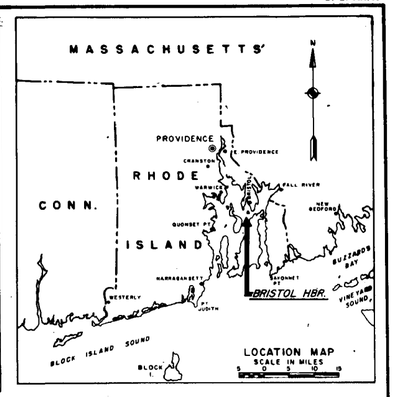
U. S. ARMY

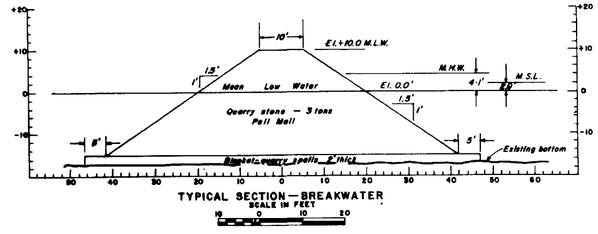


ALTERNATIVE BREAKWATER PLANS CONSIDERED

NOT RECOMMENDED







REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DR. BY E.J.B. | TR. BY A.D.C. | CH. BY

PROJECT ENGINEER

CHIEF, ENGINEERING DIVISION

CHIEF, PLANNING BRANCH

CHIEF, OPERATIONS DIVISION

APPROVED

DATE DEC 1966

CHIEF, ENGINEERING DIVISION

BRISTOL HARBOR, BRISTOL, RHODE ISLAND
ALTERNATIVE BREAKWATER PLANS
SCALE IN FEET
1000 0 1000 2000

TO ACCOMPANY REPORT DATED: 7 DECEMBER 1966

SCALE AS SHOWN

DRAWING NUMBER
BL-2

SHEET 3 OF 3

PLATE - 3

SURVEY OF BRISTOL HARBOR, RHODE ISLAND

APPENDIX A

PROJECT FORMULATION

1. Basic Principles. The project formulation for Bristol Harbor, Rhode Island, is based on the criteria that the proposed project must:

a. Provide a practicable and economic means of fulfilling an existing and prospective need;

b. Be more efficient than any other method of meeting these needs;

c. Consider all economic factors, beneficial and adverse, tangible and intangible;

d. Provide for a maximum of benefits over costs, or a basis for selection of plan not providing such maximum of benefits.

2. Alternative Plans of Improvement Considered.

a. Bristol Harbor has natural depths sufficient for the type and size of commercial and recreational craft that use or are anticipated to use the harbor. The harbor is sheltered from all quadrants except from the south. The principal navigation difficulties in obtaining maximum use of the harbor are associated with those due to wave action generated by winds from the southerly quadrants. Local interests stated a desire for breakwater protection from these southerly storms, suggesting breakwaters at various lengths, at several locations.

b. Brief consideration has been given a breakwater south of the Coast Guard Depot, as suggested by local interests. If it were a detached, offshore breakwater, it would require a structure to be placed in deeper water than one north of the Coast Guard Depot and would be of much greater length, to shelter the same proportionate area of the harbor. The additional outer harbor area protected would be further removed from shore and of doubtful use. Consequently, it is concluded that the cost would be of such greater

magnitude, as compared to a location north of the Coast Guard Depot, that the additional benefits, if any, would not be commensurate with the higher cost. A shore-based breakwater, bent to lie off the outer ends of the wharves in the vicinity of the Coast Guard Pier, although it would offer the most complete protection in that area, would protect only a small fraction of the harbor area, and therefore was not considered adequate for the harbor protection needs.

c. Consideration was also given to a system of three breakwaters. The system would consist of a detached central breakwater across the middle of the harbor mouth and two overlapping, land-based breakwaters located a distance of several hundred feet from the central structure, one to the north, one to the south. This system would provide complete protection to the inner harbor, particularly along the shore. However, the additional benefit from the system beyond that afforded by a single central breakwater is not sufficient to warrant the added cost.

d. As a result of the above analysis, alternative plans were then considered consisting of variations of length and height of a breakwater across the central portion of the harbor. These variations are tabulated below as Plans 1, 2, 3, and 4. Plans 1, 2, and 3 are for breakwaters with a top elevation of 10 feet above mean low water (5.9 feet above mean high water), and would be 1000, 1300, or 1600 feet long, respectively. Plan 4 is for a breakwater with a top elevation of 22 feet above mean low water, and is 1600 feet long. The comparisons of Plans 1, 2, and 3 are based on the relative costs, and relative benefits each would provide. The benefits are directly proportional to the area of shelter provided by each plan, which, in turn, determines the size of the navigation fleet benefited. Plans 1 and 2 would not afford sufficient shelter to protect the entire existing fleet and a reasonable expansion of the fleet anticipated during project life. A breakwater of greater length than 1600 feet would cost more, and based on the estimates of fleet size and protected area needed, would not add any benefits. Plan 3 therefore provides for the maximization of benefits to be derived by protecting navigation from the usual range of storms. Plan 4 is proposed with a top elevation to serve as a wave breaker at times of high water levels due to hurricane surge. A table of comparative costs, annual charges, and benefits of the 4 plans follows.

BRISTOL HARBOR, RHODE ISLAND

Detailed Estimate of Cost

7 Dec. 1966

Feature	Plan 1 1000 ft. long Elev +10	Plan 2 1300 ft long Elev +10	Plan 3 1600 ft long Elev +10	Plan 4 1600 ft long Elev +22
Quantity (tons)	76, 000	100, 000	125, 000	250, 000
Unit Price (Ton)	$10. 00	$9. 00	$8. 50	$8. 00
Contract Cost	760, 000	900, 000	1, 063, 000	2, 000, 000
Contingencies 15%	115, 000	135, 000	160, 000	300, 000
Total Construction	$ 875, 000	$1, 035, 000	$1, 223, 000	$2, 300, 000
Engineering & Design	40, 000	40, 000	40, 000	50, 000
Supervision & Admin.	74, 000	86, 000	101, 000	188, 000
Total Project Cost	$ 989, 000	$1, 161, 000	$1, 364, 000	$2, 538, 000
Aids to Navigation	24, 000	24, 000	24, 000	24, 000
Total Cost Fed & Non-Fed.	$1, 013, 000	$1, 185, 000	$1, 388, 000	$2, 562, 000
Annual Charges				
Interest & Amort. 50 yrs - 3-1/8% - . 03979	$ 40, 300	$ 47, 200	$ 55, 200	$ 101, 900
Maintenance				
Project	4, 000	5, 000	6, 000	15, 000
Aids to Nav.	600	600	600	600
	4, 600	5, 600	6, 600	15, 600
TOTAL	$ 44, 900	$ 52, 800	$ 61, 800	$ 117, 500
Benefits		$ 71, 850	$ 91, 650	$ 156, 650
B/C Ratio		1. 4	1. 5	1. 2

e. The added cost of Plan 4 is about $1, 200, 000 over that of Plan 3 and the added annual benefits and annual charges over Plan 3 to provide for this hurricane wave protection are $65, 000 and $55, 700, respectively. Plan 4 would provide a maximization of net benefits by about $9, 000, or slightly in excess of those provided by Plan 3. However, the Town of Bristol has indicated it is neither capable nor willing to participate in the much more costly Plan 4 to obtain this slight increase in net benefits. In view of the above, the project found to best fit the criteria for project formulation is Plan 3.

APPENDIX B

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

October 20, 1961

Division Engineer
New England Division
U. S. Army, Corps of Engineers
424 Trapelo Road
Waltham 54, Massachusetts

Dear Sir:

This letter constitutes our conservation and development report on Bristol Harbor, Rhode Island navigation project and was prepared in cooperation with the Rhode Island Division of Fish and Game and has its concurrence.

Improvements under consideration consist of constructing a breakwater at the entrance to the harbor.

We conclude that there will be no significant adverse effects on fish and wildlife resources as a result of construction of the breakwater.

We have determined that the improvements would reduce storm damages to the fishing boats based in the harbor and would increase available anchorage area; however, no monetary analysis of these benefits has been made since they are not related directly to the maintenance or development of the fishery resources.

We anticipate no further studies by this Service on your proposed improvement of Bristol Harbor, Rhode Island.

Sincerely yours,

John S. Gottschalk
Regional Director
Bureau of Sport Fisheries & Wildlife

John T. Gharrett
Regional Director
Bureau of Commercial Fisheries

TREASURY DEPARTMENT
UNITED STATES COAST GUARD

Address reply to:
COMMANDER (o)
1ST COAST GUARD DISTRICT
1400 CUSTOMHOUSE
BOSTON, MASS. 02109

11410/1
21 MAY 1965

From: Commander, First Coast Guard District
To: Division Engineer, U. S. Army Engineer Division
New England Corps of Engineers, 424 Trapelo Road
Waltham, Massachusetts

Subj: Navigation Study of Bristol Harbor, Rhode Island

Ref: (a) C of E ltr NEDED-R, dtd 11 MAY 65

1. The proposed breakwater at Bristol Harbor will require a fixed structure at each end with a daymark and a light. First cost is estimated at $24,000.00 and annual maintenance cost at $600.00.

2. Coast Guard operations in the area are vitally concerned with the proposed location of the breakwater. A buoy depot with an associated dock is located at the position of the fixed red light indicated on the enclosure to reference (a) just northeast of the east end of the breakwater. A 180 foot buoy tender is presently assigned to Bristol for its home port. Safe access to the pier is deemed essential.

3. Therefore, it is recommended that the breakwater either be moved north of the approaches to the Coast Guard Depot or shortened so that a safe approach by the tender is assured.

C. B. LAMBERT
Acting Chief of Staff

APPENDIX C

TREASURY DEPARTMENT
UNITED STATES COAST GUARD

Address reply to:
COMMANDER (o-1)
1ST COAST GUARD DISTRICT
1400 CUSTOMHOUSE
BOSTON, MASS. 02109

· 11400
14 FEB 1966

From: Commander, First Coast Guard District
To: U. S. Army Engineer Division, New England, Corps of Engineers
424 Trapelo Road, Waltham, Massachusetts 02154

Subj: Navigation Study of Bristol Harbor, Rhode Island

Ref: (a) U.S. Army Engr. Div. NE ltr NEDED-R dtd 2 Feb 1966

1. Reference (a) requested additional comments on the affect of the proposed breakwater in Bristol Harbor on Coast Guard operations in the area.

2. Drawing #BL-1, dated October 3, 1961, which was forwarded with reference (a), indicated the area of clear approach at the east end of the breakwater. In addition, it was noted on the print that a distance of 300 feet off the east end of the breakwater was in this area marked as a clear approach.

3. The clearance distances indicated will be satisfactory for Coast Guard operations. However, information is requested concerning the probable affect of the breakwater on soundings in the approach area. Specifically, the Coast Guard is concerned as to whether or not accretion and silting might occur which would require dredging to insure continued access to the dock.

C. G. HOUTSMA
By direction

APPENDIX C

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

IN REPLY REFER TO:
NEDED-R

17 November 1966

SUBJECT: Navigation Study of Bristol Harbor, Rhode Island

TO: Commander (0-1)
First Coast Guard District
John F. Kennedy Federal Building
Government Center
Boston, Massachusetts 02203

1. Reference is made to your letter of 14 February 1966, file 11400, subject, "Navigation Study of Bristol Harbor, R. I." In the referenced letter you indicate that the proposed breakwater will be sufficiently clear of the Coast Guard Pier so as not to interfere with Coast Guard operations. However, you request advice as to whether accretion or silting might be caused in the approach area to the Coast Guard Pier as a result of the breakwater construction.

2. This matter has been carefully studied and you are advised that no shoaling will occur in the Coast Guard Pier approach area as a result of the breakwater construction. In fact the tendency will be very slightly just the reverse, due to some concentration of the tidal flow in the approach area. This effect will be very slight, and probably will produce no noticeable effect but, as stated, the construction of the breakwater will definitely not act to cause shoaling in the approach area.

FOR THE DIVISION ENGINEER:

JOHN WM. LESLIE
Chief, Engineering Division

APPENDIX D

STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS
DEPARTMENT OF NATURAL RESOURCES
VETERANS' MEMORIAL BUILDING, PROVIDENCE, R. I. 02903

FREDERICK C. LEES
DIRECTOR

DIVISIONS OF
Parks and Recreation
Conservation
Agriculture
Harbors and Rivers
Planning and Development
Enforcement

DIVISION OF HARBORS & RIVERS
301 Roger Williams Bldg.
Prov. R. I. 02908

March 1, 1966

Division Engineer
New England Division
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts

Dear Sir: Bristol Harbor, Rhode Island

I have reviewed the preliminary findings and conclusions with respect to the proposed plan of navigation improvement for Bristol Harbor, Rhode Island, prepared by your office in response to a resolution adopted July 29, 1955 by the Committee on Public Works of the U. S. House of Representatives.

The tentative plan which has been found feasible and economically justified would provide a stone breakwater, about 1600 feet long, with its top at elevation 10 feet above mean low water, located in a roughly east and west direction across the harbor just south of the U. S. Coast Guard Station. Passage for navigation would be outside the ends of the structure. It is noted that about seventy-five acres behind the breakwater would be protected from wave action, especially from the southwest and afford a sheltered anchorage for over 600 boats.

The estimated cost of the breakwater is $1,364,000, 37% of which or $505,000 would be the required local cash contribution. The proposed improvement appears to be satisfactory and should afford the important commercial fishing fleet and the numerous recreational vessels in the harbor the protection needed.

It should be clearly understood that the State of Rhode Island makes no commitment at this time with respect to sharing in the cost of the project or in participating in any of the other requirements of local cooperation, although the state has in the past contributed financially to projects of this kind.

Sincerely yours,

Henry Isé, Chief Engineer and
Chief, Division of Harbors & Rivers

HI:mp

TOWN OF BRISTOL
RHODE ISLAND

BURNSIDE MEMORIAL BUILDING

ANTHONY J. DENNIS, JR.
COUNCIL CLERK

May 18, 1966

Colonel Remi O. Renier
Acting Division Engineer
Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts

Dear Colonel Renier:

Reference is made to your letter of February 2, 1966 in which you described the tentative findings of your study for providing breakwater protection for Bristol Harbor.

The plan described as being the most feasible and economical would provide a breakwater 1600 feet long, with a top elevation 10 feet above mean low water, to protect a harbor area of about 75 acres. The project is estimated to cost $1,364,000, of which the non-Federal share would be $505,000 or 37% of the project cost.

The Town Council of Bristol has reviewed the proposed project and have been advised by the Harbor Development Committee and other parties concerned with the harbor that the proposed plan would be satisfactory and should afford the commercial and recreation vessels in the harbor the protection needed. It is also considered that a protected harbor will encourage greater use of the harbor with resulting benefit to the economy of the Town.

The Town Council, therefore, concurs in the plan of improvement. A legal commitment to meet the requirements of local cooperation cannot be made at this time since such commitment must be made by a town meeting vote. The Town Council is of the opinion, however, that the breakwater plan is necessary for the continued development of the waterfront and that the Town would be willing and able to meet the proposed requirements of local cooperation at the appropriate time.

Sincerely,

Anthony J. Dennis, Jr.
Council Clerk

AJD/cc

SURVEY REPORT ON BRISTOL HARBOR, RHODE ISLAND

APPENDIX E

BREAKWATER DESIGN

1. Wave Refraction. It has been considered in the breakwater design that in the East Passage of Narragansett Bay, from Newport Neck to the northern opening of the gap between Prudence Island and Aquidneck Island (11 mile fetch), the water depths are sufficient so that wave refraction does not occur. This assumption actually is probably unduly conservative, and refraction in this reach is such that the effective fetch (about 3 miles) should be measured from that point rather than from Newport Neck. Although this computation is considered to be unduly conservative, the wave height derived thereby is retained for use in design of the breakwater, as it is the maximum wave that could be generated by hurricane winds of 75 miles per hour over the more realistic 3 mile fetch. From the point above described to the study area in Bristol Harbor, wave refraction was studied with the following criteria and results.

Fetch	=	14 miles
V	=	47 miles per hour (Gale wind)
H_o	=	7.2 feet (Fig. 1-7, T.R. No. 4)
T	=	5.6 Sec. (" " " " ")
L_o	=	$5.12 (T)^2 = 160$ feet
b_o	=	300 feet
b	=	320 feet
K_R	=	$\sqrt{b_o/b} = \sqrt{30/32} = 0.97$
H	=	$K_R H_o = 0.97 \times 7.2 = 7.0$ feet

See Tables I and II for derivation of wave heights

BRISTOL HARBOR, RHODE ISLAND

TABLE I

Winds from S. S. E.

Fetch 2. 5 Naut. Miles

Wind Speed (MPH)	Wave Ht.	Period	Duration	
30	2. 3	2. 9	0. 6	
35	3. 0	3. 2	0. 6	
40	3. 3	3. 4	0. 5	
45	3. 6	3. 5	0. 5	
47	3. 7	3. 6	0. 4	*
50	4. 0	3. 8	0. 4	

Various wave heights that can be generated by different winds with a constant fetch of 2. 5 naut. miles

*Selected for use in the study

BRISTOL HARBOR, RHODE ISLAND

TABLE II

Winds from S. S. W.

Fetch 11 Naut. Miles

Wind Speed (MPH)	Wave Ht.	Period	Duration
25	3.5	4.1	2.2
30	4.0	4.5	1.9
40	5.8	5.2	1.7
45	6.6	5.5	1.6
47	7.2	5.6	1.6 *
50	7.4	5.7	1.6
55	8.3	6.0	1.5
60	9.2	6.2	1.4

Various wave heights that can be generated by different winds with a constant fetch of 11 Naut. miles.

*Selected for use in the study

2. Surge. As this is not a hurricane survey study, it is felt that a computation of surge or wind set-up would be beyond the scope of the report. Therefore data collected from previous studies in adjacent areas was used in determining the design still water level. The Cliff Walk, Newport, Rhode Island Beach Erosion Control Report uses the value of 6.3 feet above mean low water as a tide level occurring once a year. This Bristol Harbor report uses a tide level of 6.0 feet, which compares favorably with Cliff Walk.

Design Tide = 6.0 (Storm Tide)
L_o = $5.12\ (T)^2 = 5.12\ (5.6)^2 = 160$
d/L_o = $24/160 = 0.149$
$H/H_{o'}$ = 0.9134
$7/.9134 = H_{o'} = 7.7'$
$H_{o'}/T^2 = 7.7/(5.6)^2 = 0.244$

Fig. 61-A

α = 1.5: $R/H_{o'} = 2.0$
R = $2.0 \times 7.7 = 15.4$

Reduce by 50% for Rubble Mound
$50\% \times 15.4 = 7.7'$

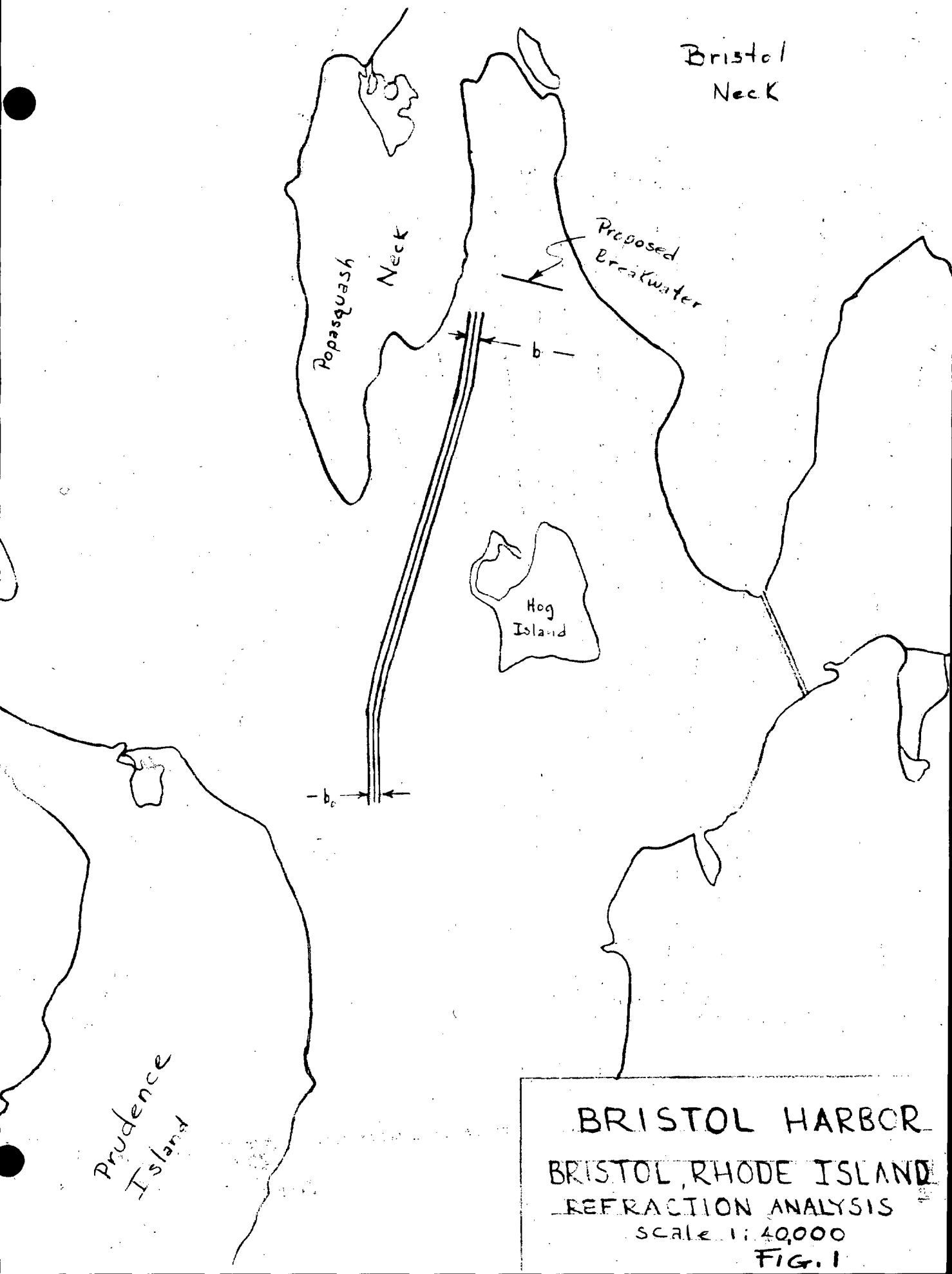
Run-up el. = $6.0 + 7.7 = 13.7'$

Breakwater El of +10 means overtopping of 3.7': Considered reasonable as waves would dissipate over 10' width of crest and occurrences of these conditions with design tide would be infrequent.

3. Diffraction. Attached diagrams consider only those waves approaching from the SSW direction. Waves from this direction are the most critical, reaching heights of 7' under design conditions. These diagrams show the results of diffraction only and are considered conservative as the waves would be further reduced by refraction after passing the proposed breakwater. Time spent on further refraction analysis would not be justified by the results obtained due to inaccuracies imposed by refraction analysis itself.

4. Results of this analysis show that the waves that approach from the SSW would be reduced to less than one foot in height by the

breakwater. Although the wharves are exposed to the waves approaching from the SSE, these waves would be at the maximum 3.7'. Enough protected area would be provided behind the breakwater for all present boats and for all boats anticipated during the life of the project.



BRISTOL HARBOR

BRISTOL, RHODE ISLAND

REFRACTION ANALYSIS

scale 1:40,000

FIG. 1

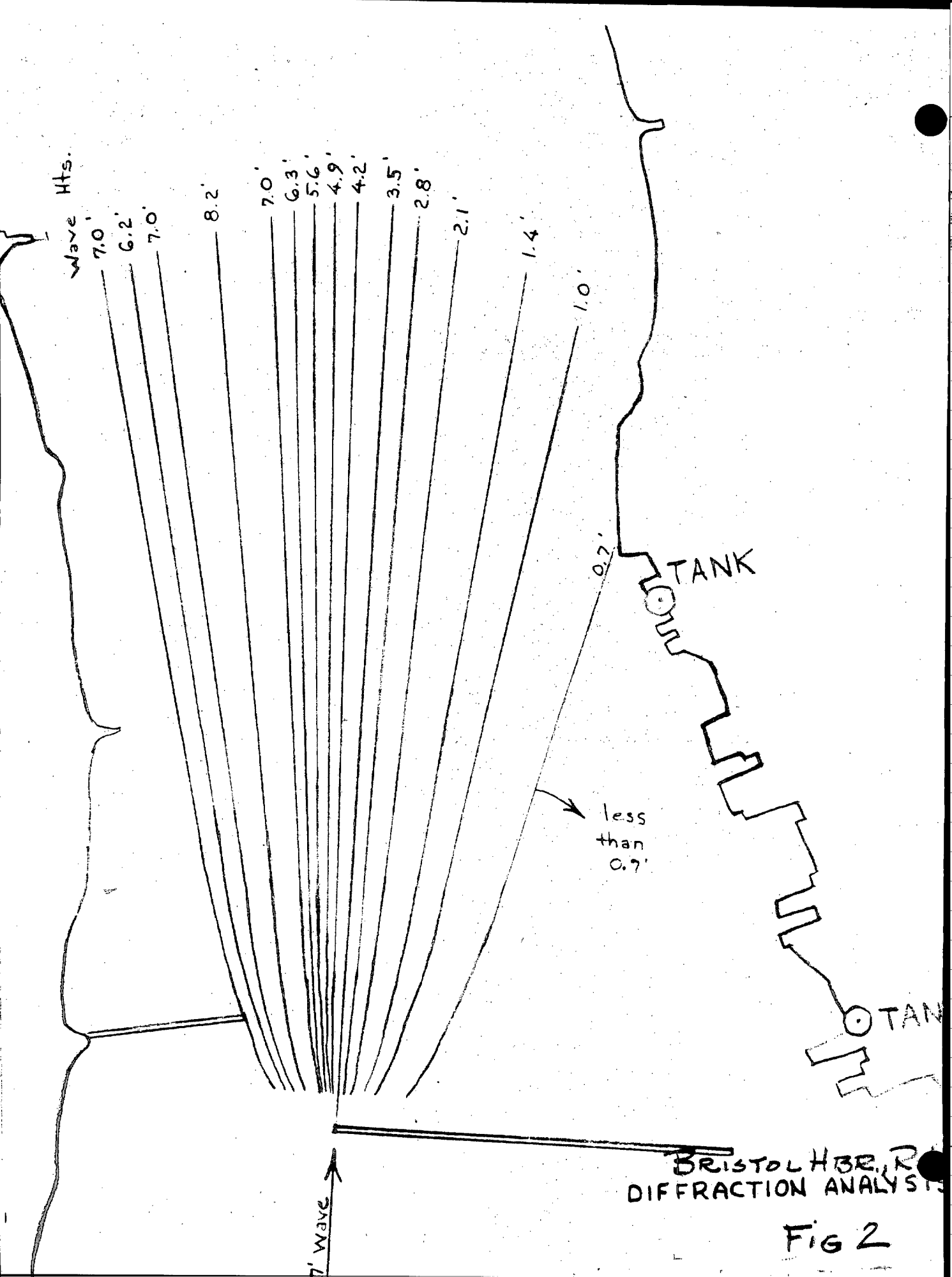
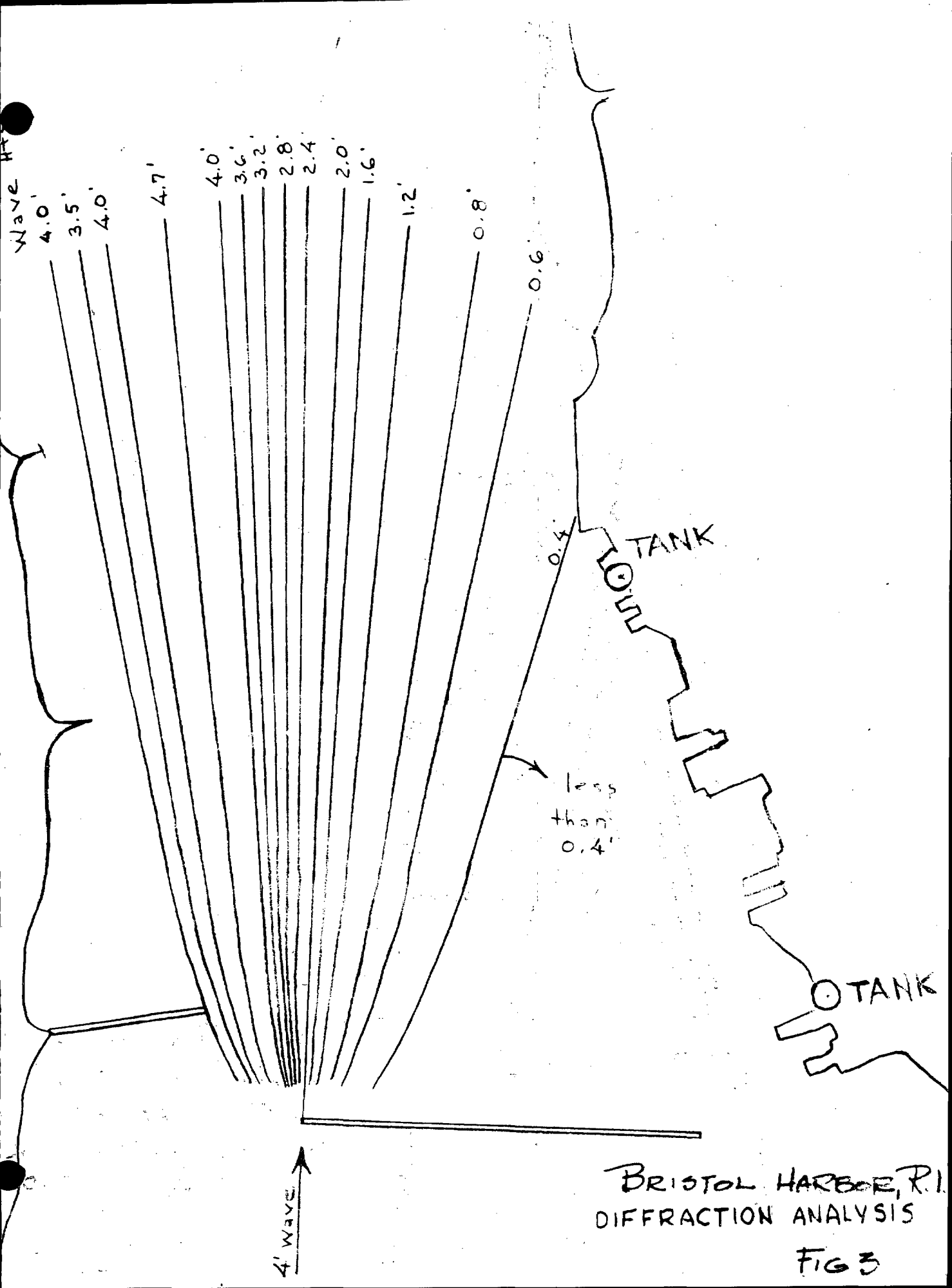
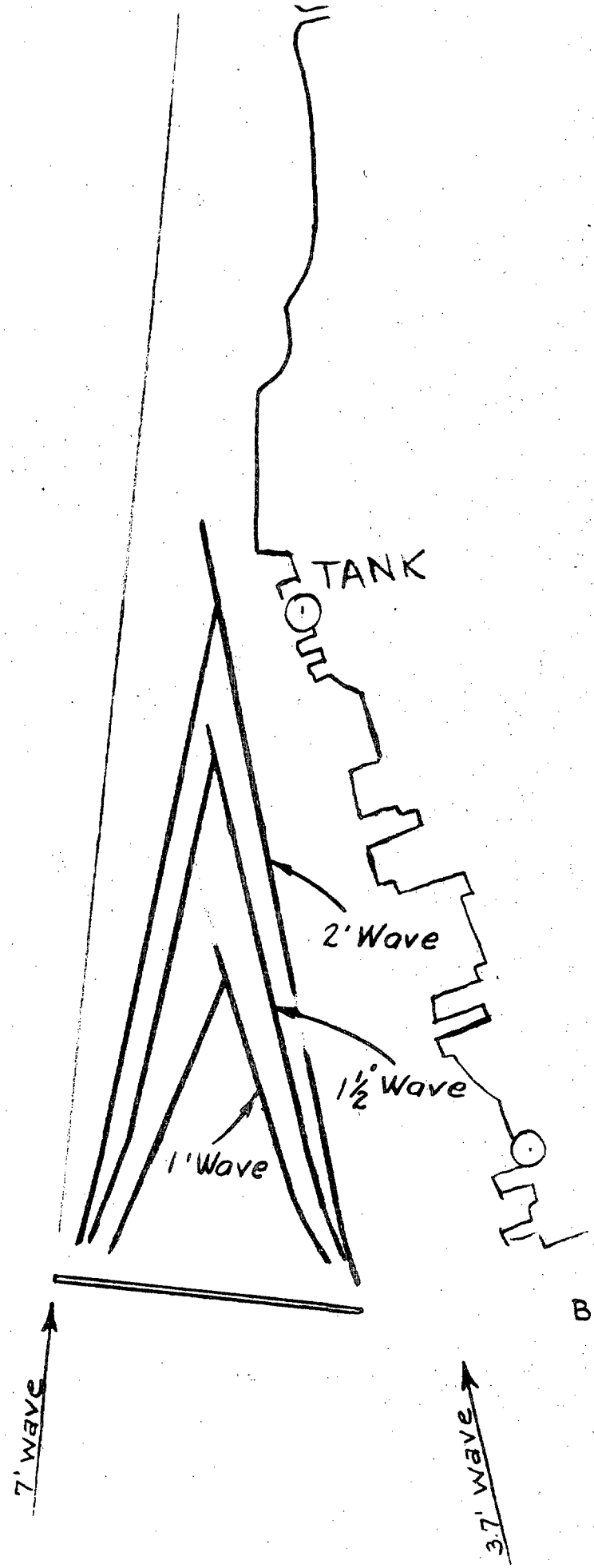

Wave Hts.
7.0'
6.2'
7.0'
8.2'
7.0'
6.3'
5.6'
4.9'
4.2'
3.5'
2.8'
2.1'
1.4'
1.0'
0.7'
TANK
less than 0.7'
TAN
BRISTOL HBR. R
DIFFRACTION ANALYSI
7' Wave

FIG 2



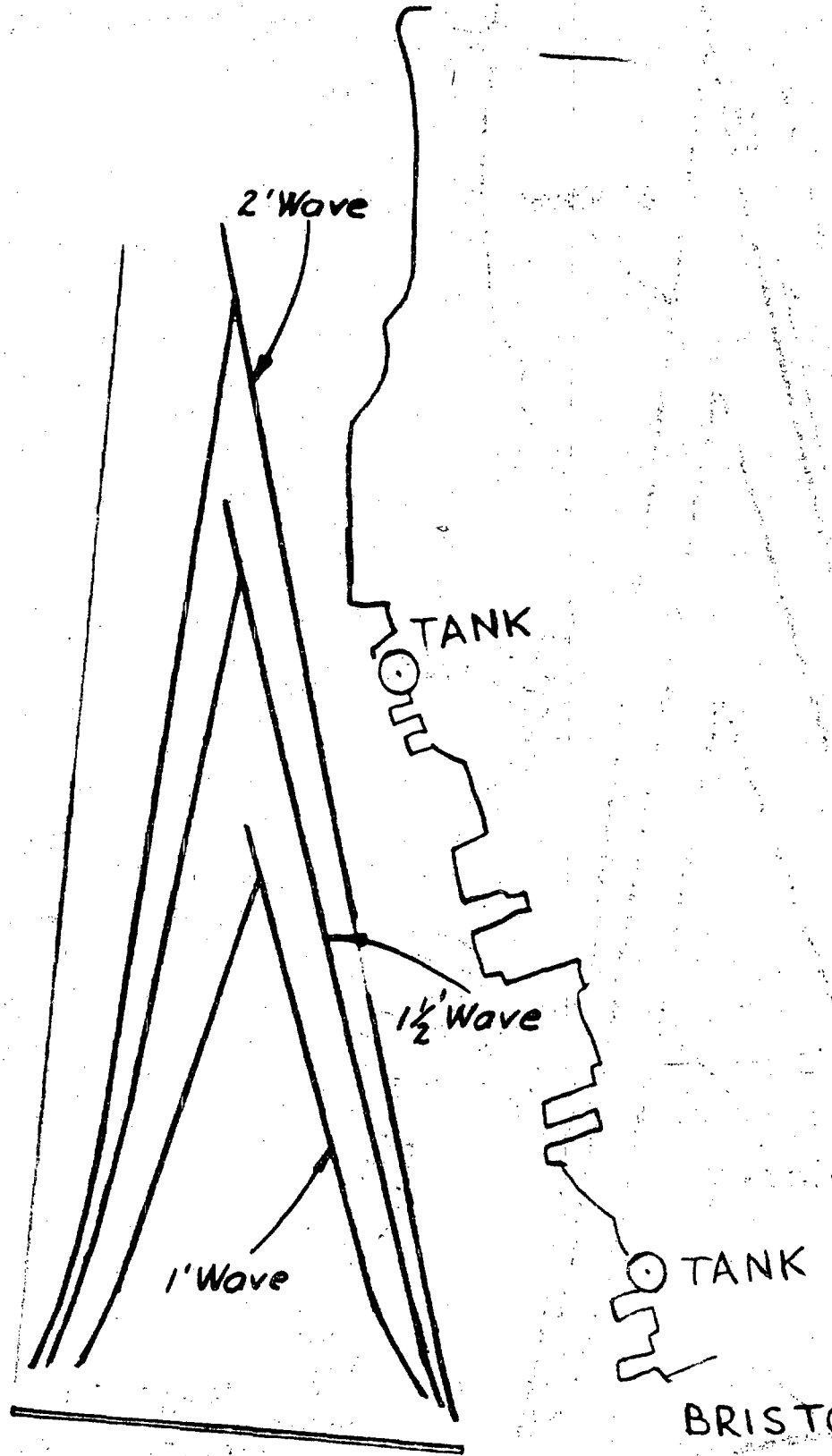
BRISTOL HARBOR, R.I.
DIFFRACTION ANALYSIS

FIG 3



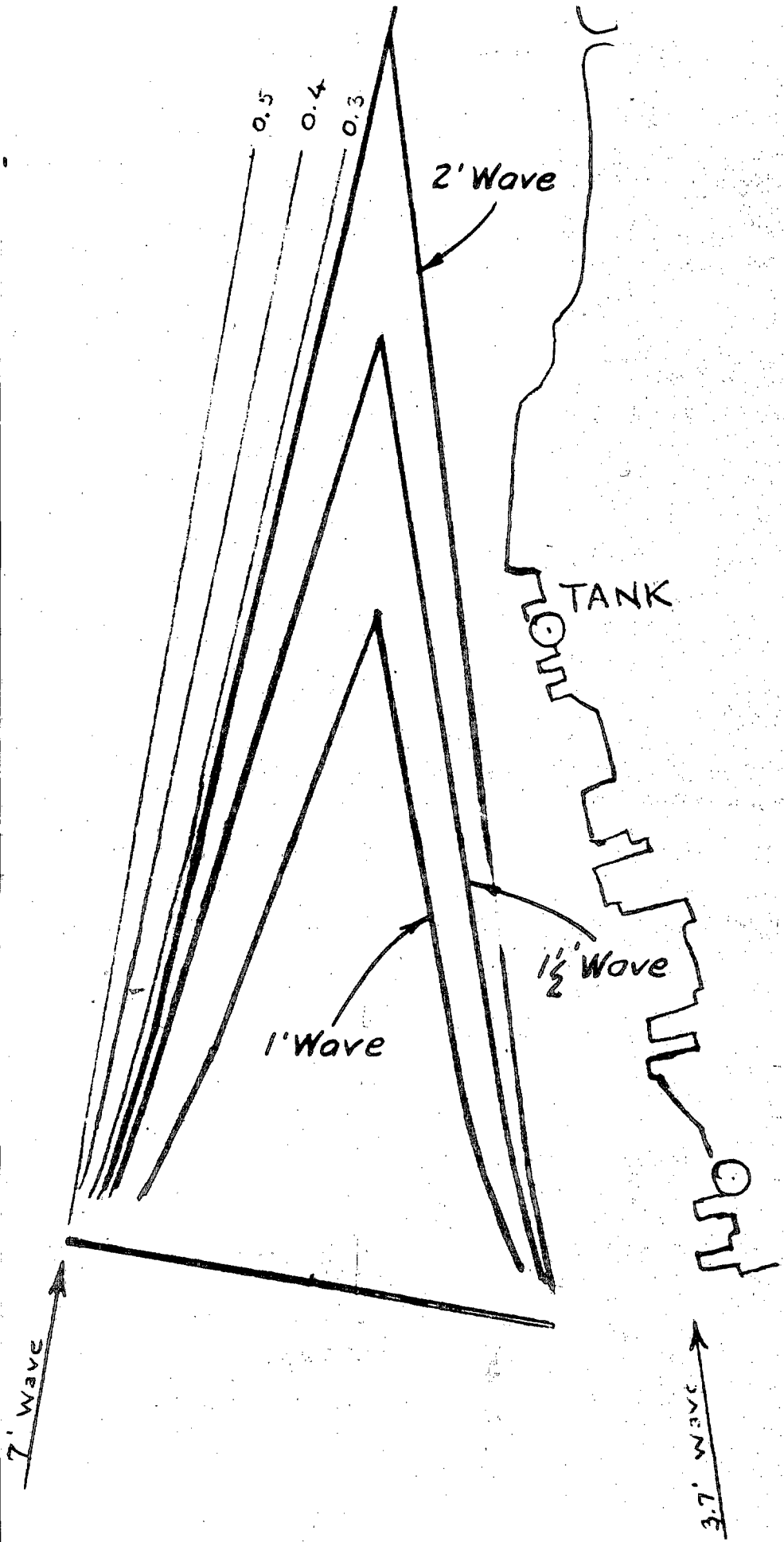
BRISTOL HARBOR
BRISTOL RHODE ISLA
DIFFRACTION DIAGRAM
1000' BREAKWATER
Scale 1" = 500

FIG. 4



BRISTOL HARBOR
BRISTOL RHODE ISLAND
DIFFRACTION DIAGRAM
1300' BREAKWATER
Scale 1" = 500'

FIG. 5



BRISTOL HARBO
BRISTOL RHODE ISL
DIFFRACTION DIAGRA
1600' BREAKWATE
Scale 1" = 50

FIG. 6

BRISTOL HARBOR, RHODE ISLAND

Information Required by Senate Resolution 148
85th Congress, Adopted 28 January 1958

1. Navigation Problems. Bristol Harbor is on the east side of upper Narragansett Bay, about 13 miles southeast of Providence. The harbor is 2 miles long north and south, and its width ranges from 1.3 miles at its mouth to 0.4 mile at its head. The harbor enjoys adequate depths ranging from 12 to 27 feet, and because of its favorable location near the head of Narragansett Bay, and the metropolitan Providence area, is intensively used as a base for a fishing fleet, recreational boating, and the U. S. Coast Guard. The harbor is landlocked on three sides, but is exposed to the south, and to storm waves built up over a 14-mile fetch in that direction. The mean range of tide is 4.1 feet, and the spring range 5.1 feet. The maximum tide of record was 16.0 feet during the hurricane of 1938. It is the exposure to southerly storms that is the principal problem to navigation in Bristol Harbor. Of somewhat less significance is the harbor and shore damage caused by relatively infrequent hurricanes.

2. Improvements Considered. Local interests requested a breakwater to protect the harbor. Three major alternatives of breakwater construction were considered; namely, a shore-based breakwater partially encircling the most intensively developed wharf area, a series of 3 breakwaters on a staggered alignment crossing the entire harbor, and an offshore breakwater across the central half of the harbor. The first alternative was rejected as protecting too small a part of the harbor, and the second as much more costly for limited additional harbor protection beyond that afforded by the third alternative, which provided the maximum excess of benefits over costs. The third alternative was also studied in four variations, three of which dealt with the length of breakwater to be provided, all with a top elevation to afford protection from normal storms. The fourth variation considered added height to the breakwater to afford wave protection during high flood conditions at times of hurricanes.

3. Improvement Recommended. The improvement recommended is the longest of the considered offshore breakwaters, but with height to protect against ordinary storms and not fully protect the harbor during hurricanes. The incremental breakwater lengths over the shorter alternatives considered are justified by the added benefits

received. Although a breakwater of a height to protect against hurricanes would provide added benefits slightly in excess of the added cost, the added cost is of such magnitude that local interests are unable to undertake the local share of cost of such a project. The recommended improvement, therefore, consists of an offshore breakwater 1600 feet long with a top elevation 10 feet above mean low water.

4. First Cost of Improvement. The estimated first costs of construction of the breakwater are based on prices for similar construction in this region prevailing in June 1966. The costs are detailed, as follows:

Corps of Engineers	
Breakwater	$1,063,000
Contingencies	160,000
Construction Cost	$1,223,000
Engineering and Design	40,000
Supervision and Administration	101,000
Total Corps of Engineers Cost	$1,364,000[1]
U. S. Coast Guard	
Additional Navigation Aids	$ 24,000
	$1,388,000

[1] Exclusive of $7,500 for preauthorization studies

5. Annual Costs and Benefits. Annual charges are based on anticipated 50-year project life and at an interest rate of 3.125 percent for both Federal and non-Federal interests. An allowance for average annual maintenance is included in the annual charges.

6. Benefits are based on commercial fishing and recreational boating, and on prevention of storm damages to both types of craft. The annual benefits are estimated to total $91,650, of which $58,950 are considered general and $32,700 local. On this basis local

interests should share in construction costs in proportion to the local benefits to be derived, computed as 36 percent local and 64 percent general.

a. Estimated Annual Charges (50-year project life)

Corps of Engineers

	Federal	Non-Federal	Total
Interest and Amortization	34,800	19,500	54,300
Maintenance	6,000	---	6,000
Total	40,800	19,500	60,300
U. S. Coast Guard			
Interest and Amortization	1,000	---	1,000
Annual Maintenance	600	---	600
Total	1,600		1,600
Total Annual Charges	$42,400	$19,500	$61,900

b. Benefit - Cost Ratio : - 1.5

Computed on a 100-year project life, the annual charges would total $52,100, and the benefit-cost ratio would be 1.8.

7. Apportionment of Cost and Local Cooperation. As the benefits to be realized are partly general and partly local in nature, local interests should contribute in cash a proportionate share of the first cost of construction, presently estimated at $1,364,000 (June 1966). The improvement is recommended subject to requirements that local interests:

a. Make a cash contribution of 36% of the first cost of construction of the breakwater, said contribution currently estimated at $491,000 (1966) to be paid in a lump sum prior to initiation of construction, and subject to final adjustment after actual costs have been determined.

b. Provide, without cost to the United States, all lands, easements, and rights-of-way necessary for construction and maintenance of the project when and as required. Rights-of-way should include access to a contractor with his equipment to construct the breakwater from land.

c. Hold and save the United States free from damages that may result from construction and subsequent maintenance of the project.

d. Provide assurances that the existing public landings or their equivalent will be adequately maintained during the life of the project and will be open to all on equal terms.

e. Establish regulations prohibiting discharge of untreated sewage, garbage and other pollutants in the waters of the harbor by users thereof, which regulations shall be in accordance with applicable laws or regulations of Federal, State and local authorities responsible for pollution prevention and control.